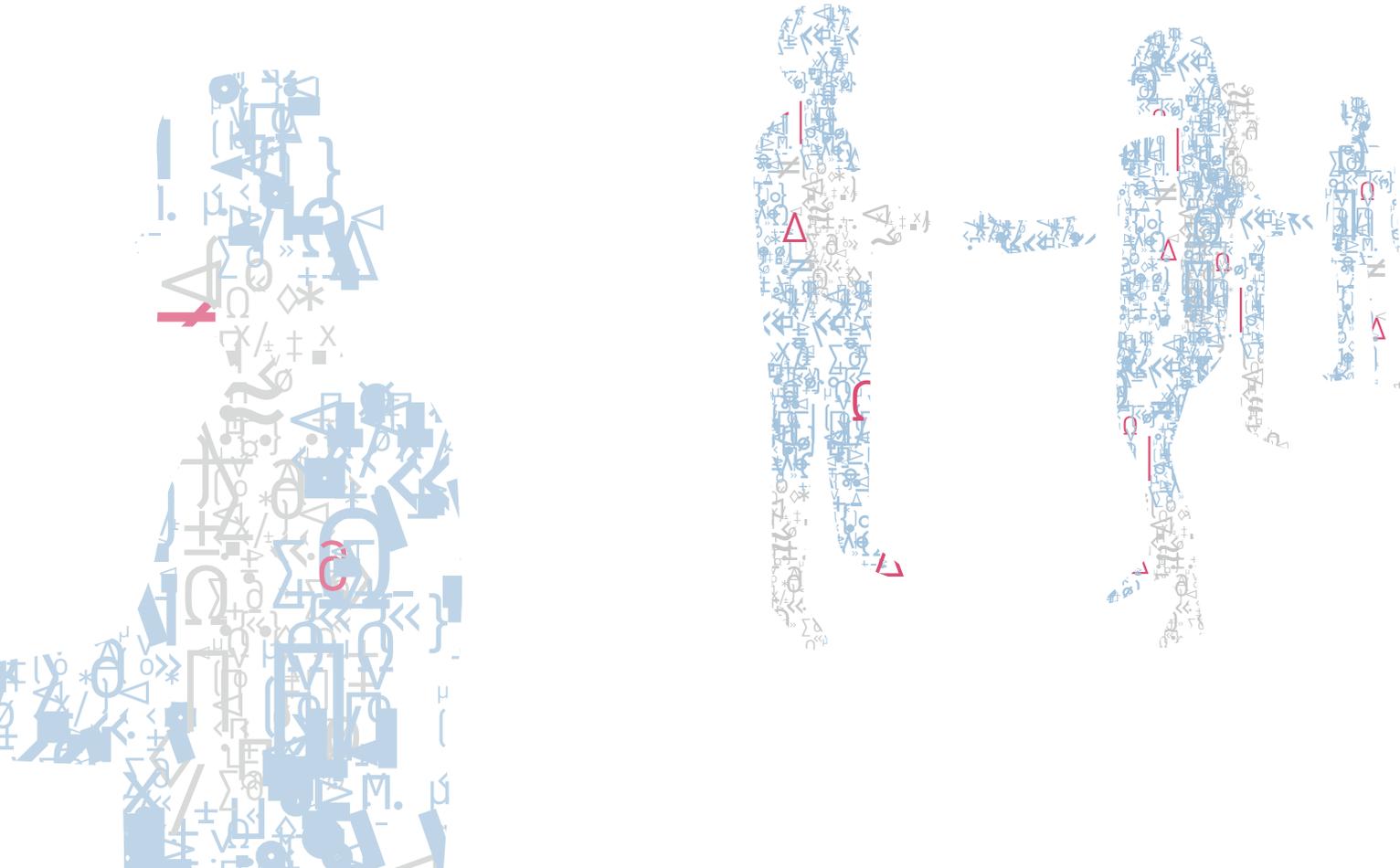


SUMMARY OF ACTIVITIES 2009

THE ABDUS SALAM INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS





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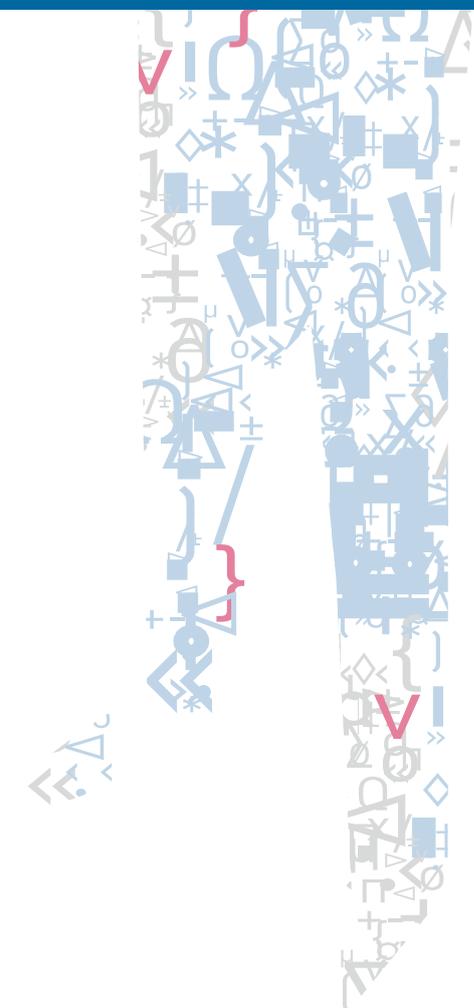


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Background and Introduction

For more than 45 years, the Abdus Salam International Centre for Theoretical Physics (ICTP) has provided scientists from developing countries with opportunities to conduct research and to study the latest advances in physics and mathematics. The scope of the activities has since broadened to include applied and related fields of science.

ICTP's success is based on a strong foundation of two core activities: research and training. Its in-house staff of world-class physicists and mathematicians perform research at the cutting edge of their fields, the results of which are published in select physics and other science journals.

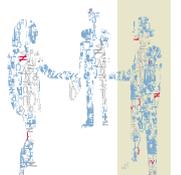
Concurrently, the Centre provides exceptional training and educational opportunities at home and abroad to scientists from developing countries. ICTP strives to maintain a stimulating environment that remains responsive to the needs of world-class scientists without neglecting the needs of researchers, particularly young researchers from the developing world, to remain at the forefront of their fields. The Centre sponsors a number of initiatives, including an Associateship Scheme, to provide research and training opportunities in physical sciences. Such initiatives have now been adopted by many other institutions throughout the world.

ICTP welcomes about 6,000 scientists each year to its campus. Of the 100,000 scientists (from 170 countries and 45 international organizations) who have participated in Centre activities since 1964, about 50 percent have come from Asia, Africa, Latin America and Eastern Europe. Over the past decade, the number of women participating in ICTP activities has increased steadily and now stands at 22 percent.

ICTP operates under a tripartite agreement between Italy, the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the International Atomic Energy Agency (IAEA). The Centre is located on the coast of the Adriatic Sea, in northeast Italy, about seven kilometres from the city of Trieste.

The following pages paint a brief portrait of ICTP activities and achievements in 2009. More detailed information can be discovered on the CD attached to the back cover of this report.





Statement by Katepalli R. Sreenivasan

I wish to take this opportunity to convey two main points.

When it became clear that personal reasons would prevent me from continuing at ICTP beyond my nearly seven cherished years at the Centre, my main concern was to identify a suitable successor. I chose not to be directly involved after a certain point in the process, but worked to ensure that the initial slate of available candidates was strong. Fernando Quevedo was always on my list and I am immensely pleased about his choice as director. He and I are unlike in research interests and background, but alike in our commitment to developing countries and the desire to strengthen ICTP's mission. Some things at ICTP will no doubt change during his term, but the institutional mission will remain intact. Altogether, ICTP is in excellent hands.

At the time of ICTP's creation, scientists from developing countries had difficulties accessing the latest scientific data and papers, as well as meeting other active scientists. ICTP has worked assiduously to overcome this isolation. The electronic era of open source publication and reprint archives, along with travelling circuits of scientists for numerous international meetings and an increase in scientific societies has partially alleviated the problem. These days, almost all institutions of higher learning—even the Institute of Advanced Study in Princeton and CERN in Geneva—go out of their way to open doors to scientists from developing countries. Access to scientific information is still quite uneven, but the direness of the situation is abating and will improve with time. What, then, will keep ICTP unique?

Missing from the background of numerous scientists I have met over the last few years is the instinct to know what it means to do good science, and how to disseminate it: how to pose a problem, how to address its essentials, how to explain clearly one's work to others in spoken and written words, and how to lay just claims of originality for one's work. These attributes come mostly by example, and I hope that ICTP will do better in providing it: in all its programmes from the Diploma to the most advanced workshops, ICTP should emphasize the nature of the scientific process. Further, ICTP should stand firmly for quality and wisdom: Quality alone makes it possible for us to build the future on the basis of the past, and wisdom alone is the key to scientific perspective, ethical values and broader perspective on the larger human spirit. And, as a practical matter, ICTP should do more by way of thoughtful dissemination of science. I have strongly believed that what science ICTP does is less important than how well it does it and how much of the scientific culture it successfully propagates. Ultimately, the process is as important in science as the goal itself.

I wish to assure our readers that ICTP is well entrenched in my own system, and that I will continue to do anything possible to advance its spirit. I am grateful for it.

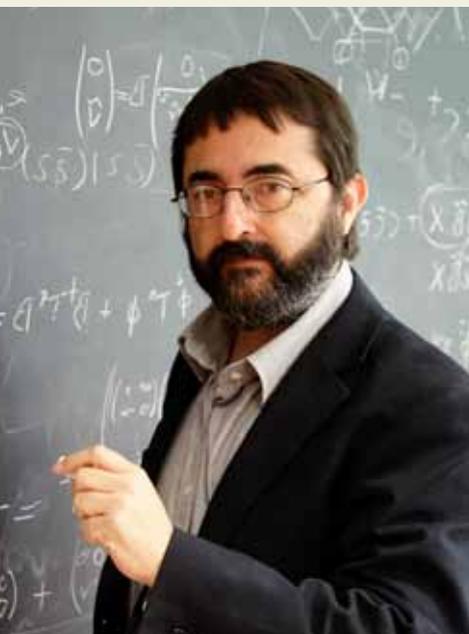


Katepalli R. Sreenivasan
Abdus Salam Research Professor

Editor's note:

Katepalli R. Sreenivasan finished his term as ICTP director in November 2009.

Statement by Fernando Quevedo



The activities presented in this summary report represent only a subset of the many achievements of ICTP during 2009. However, for me, as a new director arriving at the end of the year, this report provides an accurate portrait of the high standards that ICTP maintains as a scientific institution in all of its endeavors: research, education and outreach.

With my short experience leading ICTP, I am very inspired by the strong commitment of its scientific and administrative staff, whose work shows that the spirit of the Centre's mission is very much alive. I find this extremely important in optimizing the impact of ICTP and ensuring its success.

ICTP's activities and achievements in 2009 involved the effort of many people working as a team. I would like to take this opportunity to thank everybody who contributed to these accomplishments and hope very much to count on their full support during my mandate.

It is a great honour for me to follow in the footsteps of my predecessors and lead this unique institution during a time where science is playing an ever-increasingly prominent role in a world whose geopolitical structure is rapidly changing. This summary of activities illustrates that ICTP is at a very healthy starting point to meet these new challenges.

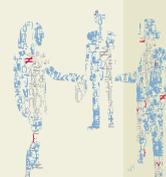
Fernando Quevedo
Director, ICTP

Editor's note:

Fernando Quevedo, a Guatemalan national, is the new director of ICTP as of November 2009.

Quevedo is a well-known theoretical particle physicist with wide-ranging research interests in string theory, phenomenology and cosmology. He obtained his PhD from the University of Texas at Austin in 1986 under the supervision of Nobel Laureate Steven Weinberg. Following a string of research appointments at CERN, Switzerland, McGill University in Canada, Institut de Physique in Neuchâtel, Switzerland, and the Los Alamos National Laboratory, USA, as well as a brief term as professor of physics at the UNAM (Mexican National Autonomous University), Mexico, Quevedo joined the Department of Applied Mathematics and Theoretical Physics at the University of Cambridge, UK, in 1998, where he was professor of theoretical physics and Fellow of Gonville and Caius College.

He was awarded the 1998 ICTP Prize in recognition of his important contributions to superstring theory. He has also received a Doctorates Honoris Causa from the Universidad del Valle de Guatemala and the Universidad de San Carlos de Guatemala, the Royal Society Wolfson Merit Award and the John Simon Guggenheim Foundation Fellowship. He is the founder and coordinator of the International Network of Guatemalan Scientists.



[A summary of ICTP achievements

February

ICTP's EyA (Enhance your Audience) recording system reaches an important milestone when it records its 3,000th hour of ICTP lectures and talks. The lectures are available on the website www.ictp.tv.



Jean-Pierre Ezin, Commissioner
of the African Union

March

ICTP and the African University of Science and Technology (AUST) sign a memorandum of understanding to establish active collaboration in training activities.

May

ICTP hosts a high-level meeting of African scientists and representatives of scientific institutions in Trieste to explore ways for ICTP to improve its effectiveness on the continent.

The Central European Initiative (CEI), in conjunction with ICTP and other Trieste System scientific institutions, initiates the CEI Research Fellowship Programme (CERES), to provide post-doctoral opportunities for nationals from CEI's Eastern European member states.

June

ICTP Director Katepalli R. Sreenivasan speaks at the conference on "Afghanistan and its geographical context: Development of a regional network of cultural and scientific cooperation", a side event to the G8 meeting organized by the Italian Ministry of Foreign Affairs and the Academy of Sciences for the Developing World (TWAS).

July

ICTP signs an agreement with the Iraqi Ministry of Higher Education and Scientific Research (MOHESR) to collaborate on physics and mathematics training for Iraqi scientists.

August

WMO and ICTP launch the South Asian Climate Outlook Forum, establishing a network of countries in South Asia that will produce improved seasonal climate forecasts.



Katepalli R.
Sreenivasan
speaking at G8
event in Trieste



A.M. Taleb of MOHESR
signing ICTP agreement



Michel Jarraud, WMO
Secretary General



September

ICTP, along with Trieste's other research and educational institutes, participates in Researchers' Night, a major science festival aimed at bringing science and scientists to the general public. It is held in Trieste's main square.



↓
Donation of HPC
in Ethiopia



October

Fernando Quevedo of Cambridge University, UK, a Guatemalan national, is appointed as the new director of ICTP. He had won the ICTP Prize in 1998.

ICTP donates high-performance computing (HPC) equipment worth €25,000 to Addis Ababa University in Ethiopia. The donation was made possible by funds from the Italian government and UNESCO.

↑
Researchers' Night
activity

November

Fernando Quevedo begins his tenure as ICTP director.

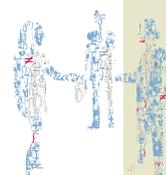
ICTP opens its Darwin Exhibit celebrating the bicentennial of Darwin's birth. The exhibit includes relics of ancient life, from dinosaur eggs to hominid remains, as well as information about Darwin's life and accomplishments.



↑
A display at ICTP's
Darwin Exhibit



↑
Fernando Quevedo



+ Awards and Prizes 2009

ICTP supports a prestigious awards programme that recognizes some of the world's most eminent theoretical physicists and young mathematicians. Since 1985, ICTP has awarded its esteemed Dirac Medal to theoretical physicists, many of whom have gone on to win Nobel prizes. The Centre also awards the ICTP Prize, the Ramanujan Prize for Young Mathematicians from Developing Countries (funded by the Niels Henrik Abel Memorial Fund), and the International Commission for Optics (ICO) /ICTP Gallieno Denardo Award.

The 2009 **Dirac Medal** recognized the joint contributions of Roberto Car, Chemistry Department at Princeton University, and Michele Parrinello, Swiss Federal Institute of Technology (ETH Zurich), for their revolutionary “molecular dynamics” numerical simulation method for condensed matter. The method has provided an all-important quantitative understanding of the properties of matter, while also allowing scientists and laypeople alike to visualize atoms in motion during physical and chemical processes.

The 2009 **ICTP Prize**, which recognizes outstanding and original contributions in physics and mathematics by young researchers from developing countries, was awarded to Professor Marcelo Barreiro, Universidad de la República, Montevideo, Uruguay, for his important contributions to the field of tropical Atlantic variability, and the exploration of dynamical mechanisms to explain the palaeo-climatic record in the last few million years. The results of his investigations have important implications for seasonal forecasting and the climate change debate.

The **Ramanujan Prize** is awarded annually to a researcher less than 45 years of age from a developing country who has conducted outstanding research in any branch of the mathematical sciences. The 2009 prize was awarded to Ernesto Lupercio, CINVESTAV, Instituto Politécnico Nacional, Mexico, in recognition of his outstanding contributions to algebraic topology, geometry and mathematical physics.

The **ICO/ICTP Gallieno Denardo Award** recognizes a researcher less than 40 years of age from a developing country who has made significant contributions to the field of optics. The award recipient for 2009 was Saifollah Rasouli, Institute for Advanced Studies in Basic Sciences, Zanjan, Iran, for his creative implementation of Moiré interferometry to fiber optics, optical metrology and atmospheric optics, including measurements of turbulence parameters, and possible applications to wavefront distortion compensation in adaptive optics systems.

↓
Roberto Car (left)
and Michele Parrinello



↓
Saifollah Rasouli

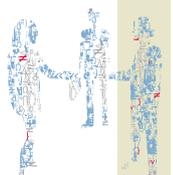


2.0 ICTP Research



ICTP is an institution that is run by scientists for scientists. Without a strong internal core of research, an institution like ICTP cannot disseminate knowledge effectively. Thus, ICTP has fostered research groups in several areas of physical sciences and mathematics, including high-energy physics, condensed matter and statistical physics, and Earth system physics. ICTP also supports a number of applied physics activities.

The bulk of the research at the Centre is carried out by the staff of these scientific sections and their consultants, along with long-term and short-term visitors engaged in independent or collaborative research, a relatively large cadre of post-doctoral fellows, and participants of ICTP's Associateship Scheme.



High Energy, Cosmology and Astroparticle Physics

The High Energy, Cosmology and Astroparticle Physics (HECAP) section at ICTP is studying some of the most exciting areas in physics today, from string theory to physics at large energy colliders, from neutrino phenomenology to alternative cosmologies. In 2009 they performed research in three main directions:

- phenomenology of particle physics;
- cosmology; and
- string and higher dimensional theories.

[Phenomenology of Particle Physics

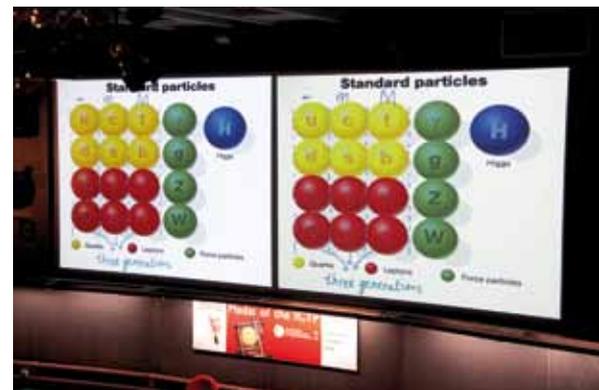
Particle physics phenomenology bridges theoretical physics (such as quantum field theory and theories of the structure of spacetime) and experimental particle physics. Research highlights in this branch of HECAP covered the following areas in 2009:

+ Neutrino phenomenology

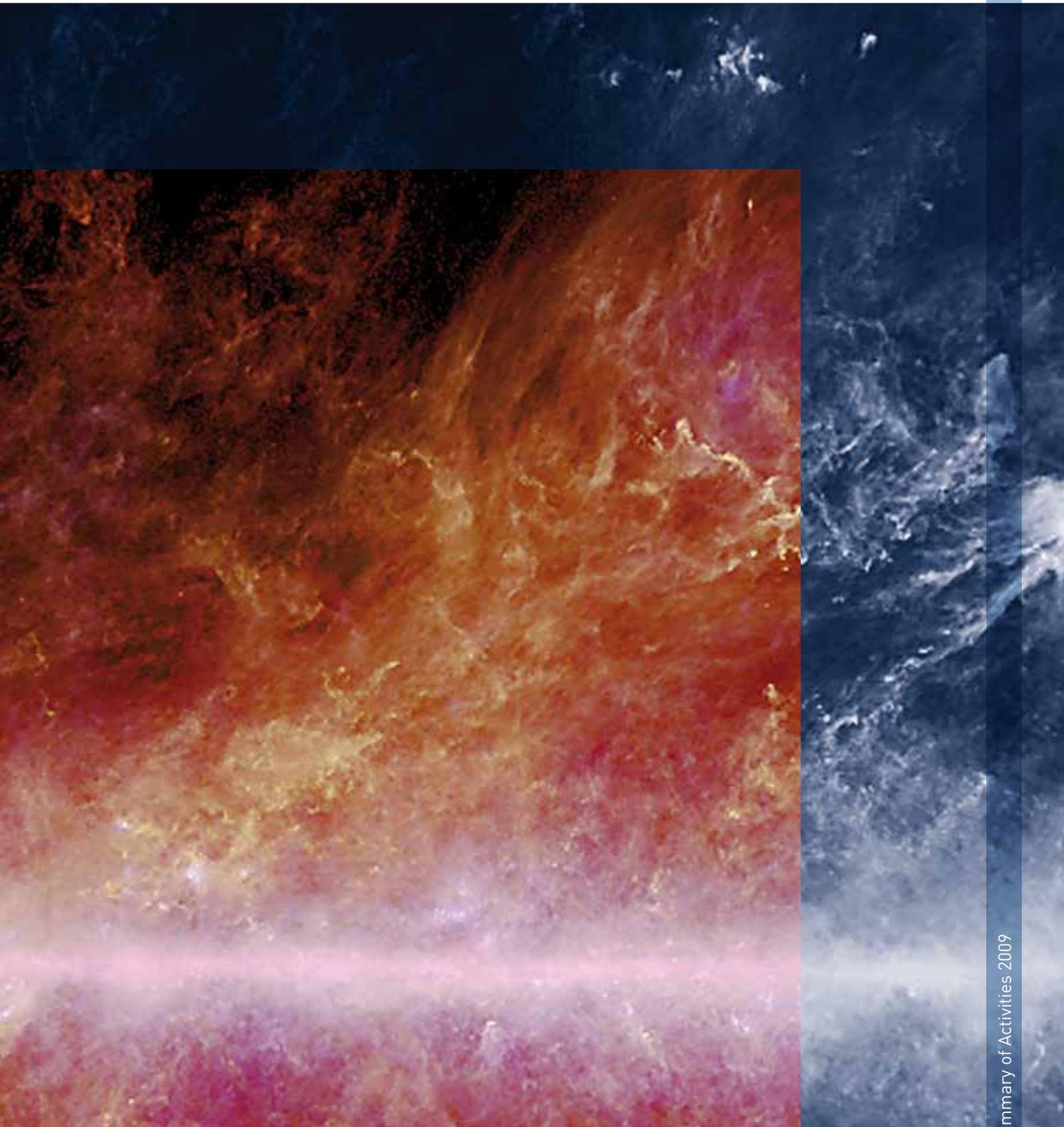
- A theory of oscillations of very low energy atmospheric neutrinos (one of still missing elements of the neutrino phenomenology) has been elaborated;
- A novel approach to calculation of the neutrino oscillation probabilities in the wave packet picture, based on the summation conventions different from the standard one has been developed. It gives a new insight into the oscillation phenomenology. A number of subtle points and “paradoxes” are clarified;
- Phenomenon of multiple spectral splits of supernova neutrinos has been uncovered. Collective oscillations of supernova neutrinos swap the electron neutrino and antineutrino spectra with those of another flavor in certain energy intervals bounded by sharp spectral splits. This phenomenon can lead to interesting observational consequences;
- High-energy cosmic neutrino fluxes can be produced inside relativistic jets under the envelopes of collapsing stars. A comprehensive (both analytic and numerical) description of the flavor conversion of these neutrinos is developed.

+ Astroparticle physics

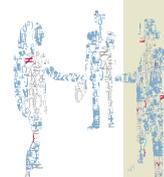
- A new model of dark matter (DM) has been proposed where the dark sector is an identical copy of the standard model (SM). In addition to gravity, the SM and DM sectors are connected by heavy right-handed Majorana neutrinos. The out of equilibrium decay of these neutrinos produces equal lepton asymmetries in both sectors via resonant leptogenesis which later get converted to baryonic and dark baryonic matter. This explains why they have relic abundance of the same order. The lightest nucleon in the dark (mirror) sector is a candidate for dark matter;



Slide from lecture
by Dirac Medallist
Cumrun Vafa



Dust structures within 500 light-years of the Sun (©ESA and the HFI Consortium, IRAS)



- Constrained minimal supersymmetric model (CMSSM) is considered with addition of the right-handed neutrino superfields which have masses close to the GUT scale. The effects of these right-handed neutrinos on the low energy SUSY spectrum is explored. It is shown that the light (left-handed) sneutrino can be the next-to-lightest supersymmetric particle with either the neutralino or gravitino as the lightest supersymmetric particle. In this scenario there are new ‘sneutrino coannihilation regions’ which yield the desired thermal neutralino relic density;
- The leptogenesis scenario, the so called “annihilating leptogenesis”, is proposed, where the lepton asymmetry is generated through annihilations, rather than decays, of heavy particles;
- The generic leptogenesis constraints on the symmetry breaking scale of global lepton number are obtained;
- Various connections of the leptonic dark matter suggested by the ATIC and PAMELA results on cosmic electron and positron excesses to the neutrino mass generation are proposed. A double type-II seesaw model is constructed for generation of neutrino masses and baryon asymmetry. The Higgs triplet can remain light and be accessible at the LHC. It can mostly decay into the leptons which can explain the positron and electron excesses observed by PAMELA through the annihilation of dark matter into the Higgs triplet. A lepton asymmetry is produced and stored in the Higgs triplet to account for the matter-antimatter asymmetry in the universe;
- The origins of dark and visible universe are unified in a variant of the seesaw model: The dark matter relic density is a dark matter asymmetry emerged simultaneously with the baryon asymmetry from leptogenesis; the dark energy is due to a pseudo-Nambu-Goldstone-Boson associated with the neutrino mass-generation.

2.1

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+ Phenomenology at the Large Hadron Collider (LHC) and other high-energy colliders

- The minimal realistic $SU(5)$ grand unified theory predicts the seesaw through weak fermion triplets with a mass below TeV. An in-depth study of consequences of this theory for colliders such as Tevatron and LHC has been performed. Of particular interest is LHC which offers a great hope of observing these particles with a spectacular signature of direct Lepton number violation. This can serve to probe the CP violating phases of the leptonic sector;
- Phenomenology of an extended Higgs sector with various non-minimal couplings has been explored. In particular, the low energy constraints on “leptophilic” two Higgs doublet model and its tests at the LHC and ILC have been studied;
- Production of the Higgs bosons with lepton flavor violating (LFV) couplings at electron-photon collider (ILC option) have been considered. The collinear enhancement of the process $e + \gamma \rightarrow H + l$ has been uncovered;
- Effects of the anomalous Higgs couplings (in particular, due to dimension-six operators) on the Higgs boson production at the Large Hadron Collider are explored;
- Cross-section of the Higgs boson pair production at a photon-photon collision is computed

in the two Higgs doublet model. Detection of this process will allow one to determine the Higgs self-coupling constant. It is shown that the cross-section can be enhanced for several reasons.

+ Flavor physics

- Information on the leptonic CP-phases can be obtained by studying correlations between the polarization of the initial muon state scattered off nuclei and the final state particles, the so-called triple product correlations. These P, CP and T violating triple correlations have been studied for muon to electron conversion in nuclei. It was found that in the simple seesaw mechanisms of all three types, the correlations are negligible. In contrast, in the left-right symmetric theories, the effects can be observable in future experiments, as long as the scale of left-right symmetry breaking lies below 10-30 TeV. This provides a further boost for muon to electron conversion experiments which could help probe the theory behind neutrino mass;
- Collider (in particular, the LHC) signatures of flavon models based on global U(1) flavor symmetry have been studied. Flavons which have FCNC Yukawa interaction affect low energy observables. The production rate and the decay branching ratios of the flavons have been computed;
- The constraints on the Higgs triplet model from LFV processes such as tau rare decays and the muonium conversion have been found;
- It is shown that the problem of mass ratios of the lighter fermion generations within the minimal SU(5) GUT can be resolved in supersymmetry with large soft A-terms. One can achieve simple unification for lighter generations without additional Higgs multiplet, while having sfermions lighter than 1 TeV. The presence of such large A-terms makes the sfermion mass spectrum distinct from the universal SUSY breaking sector. The implications of these splittings are studied in K- and D-meson oscillations and in rare processes $D \rightarrow \pi + \nu + \text{anti-}\nu$ and $K \rightarrow \pi + \nu + \text{anti-}\nu$, and in the latter case the effect is found to be important.

[Cosmology

Cosmology, the study of the large-scale structure and the evolution of the universe, has in the last few years entered a qualitatively new phase, driven by a host of experimental results. In 2009, the Cosmology group studied:

- Clustering dark energy: The energy component responsible for the observed acceleration of the universe, the so-called dark energy, is usually assumed to be smooth across the universe and not actively participating in the formation of astrophysical objects. The ICTP Cosmology group has proposed a model (quintessence with zero speed of sound) where dark energy participates in the gravitational collapse, which leads to the formation of structures in the universe. The phenomenology of this model is very rich and various experimental signatures are under investigation, particularly the effect on the physics of galaxy clusters;



- **Non-Gaussianity:** This is a hot topic in the field and encompasses all phenomena that are not captured by the linear approximation to cosmological perturbations. It has been a main line of research for the ICTP group in the last few years. This year the group calculated the model-independent contribution to the Cosmic Microwave Background Non-Gaussianities on large angular scales, generated by General Relativity. This represents an important theoretical input for the forthcoming Planck satellite results. The group is also actively involved in the planning of the future experimental satellite missions, especially regarding the discovery of non-Gaussianity;
- **Eternal Inflation:** This describes the regime of inflation where an infinite amount of space is created, giving rise to so-called parallel universes. In 2009, the ICTP Cosmology group organized a successful conference on this subject, gathering all the experts in the field, and it has studied quantitatively the conditions for the existence of this primordial cosmological phase.

[Strings and Higher Dimensional Theories

String theory combines quantum mechanics and general relativity into a quantum theory of gravity that attempts to describe all the known natural forces and matter in a mathematically complete system. In string theory the electrons and quarks inside an atom are vibrational modes of one-dimensional extended objects, relativistic strings.

- In 2009, the main activities in string related areas were centred around holographic QCD and holographic hydrodynamics. The idea here is to understand a particularly strong coupling phenomenon on the boundary of AdS space-time by using the holographic description in terms of the bulk gravity theory. Among the various results, a study of the Z_N vacua in the presence of fundamental quarks was carried out and it was shown that at temperatures higher than the mass scale of the quarks these Z_N vacua are lifted and the corresponding energy difference are calculated. Another work was computing the Nucleon-Delta electromagnetic form factors using holographic QCD and the results obtained were in good agreement with the experimental results.

Non-linear hydrodynamics with the aim of application to QCD plasma incorporating abelian and non-abelian global symmetries was studied using holography. Another set of papers were devoted to studying the effects of the Chern-Simons terms in 5-dimensional gauged supergravity which is holographically responsible for chiral anomalies in 4-dimensional gauge theories. The results included a study of chiral magnetic conductivity as well as chiral dependence on the hydrodynamic waves in the presence of $U(1)$ R-charge chemical potential;

- Another direction of work was in topological string theory. A new class of $N=2$ topological amplitudes was obtained generalizing the well known F_g . The novel feature of these new topological quantities is that they depend both on vector and hyper multiplets.



↑
Dirac Medallist
Joseph Polchinski
lecturing on
string theory

The differential equations that characterize these new F-terms are obtained and include the usual holomorphicity with regard to vector moduli as well as harmonicity equations with regard to hyper moduli;

- A consistent formulation of an interacting theory of massive spin-2 particles is a long-standing unsolved problem. A model with dynamical torsion has been studied in detail and has been shown to pass some consistency checks that the generalizations of the well known Fierz-Pauli theory have failed to pass. It has been shown that in a wide class of curved backgrounds the spectrum is ghost and tachyon free. The massive spin-2 particle originates from torsion and satisfies a generalization of the Fierz-Pauli equation which reduces to the latter when the background is flat. A novel aspect of this model is that even a symmetric conserved energy momentum tensor can give rise to torsion degrees of freedom. This may have interesting astrophysical relevance. Gravity is expected to be modified in the infrared with possible application to the study of some of the unsolved problems of cosmology. More work is in progress to show the full consistency of such models;
- A thorough investigation of the spectrum of a class of brane solutions in minimal gauged supergravity in six dimensions has been carried out. This is the completion of a work that had been initiated in previous years and now the full spectrum has been completed. This includes spin zero, one and two sectors as well as a large part of the fermionic sector.

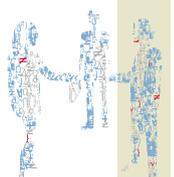
+ HECAP Publication Highlights

Arhrib, A.; Bajc, B.; Ghosh, D.K.; Han, T.; Huang, G.Y.; Puljak, I.; **Senjanovic, G.** 2009. Collider signatures for heavy lepton triplet in type I+III seesaw. arXiv:0904.2390 [hep-ph]

Creminelli, P.; D'Amico, G.; Norena, J.; Senatore, L.; Vernizzi, F. 2009. Spherical collapse in quintessence models with zero speed of sound. arXiv:0911.2701 [astro-ph.CO]

Dasgupta, B.; Dighe, A.; Raffelt, G.G.; **Smirnov, A.Yu.** 2009. Multiple spectral splits of supernova neutrinos. *Phys. Rev. Lett.* **103** 051105

Nikiforova, V.; Rubakov, V.; **Randjbar-Daemi, S.** 2009. Infrared modified gravity with dynamical torsion. *Phys. Rev. D* **80** 124050



ICTP's Condensed Matter and Statistical Physics (CMSP) section investigates the physics of disordered, mesoscopic and strongly correlated electron systems, and electronic structure and condensed matter computer simulations. Because many of the concepts and methods in condensed matter physics have at their core some elements of statistical and nonlinear physics, a significant amount of research in this section is devoted to statistical mechanics and applications.

[Disordered, Mesoscopic and Strongly Correlated Electron Systems

Understanding the electronic behaviour of strongly correlated electron systems is one of the most important problems in condensed matter physics, one that is driving a revolution in the study of solids that produce exotic properties such as high-temperature superconductivity. Research by CMSP in this area included topics related to theoretical nanophysics, localization, quantum systems out of equilibrium, low-dimensional systems with interaction, strong electron correlations in new materials, disordered superconducting and superfluid systems, and cold bosonic and fermionic atoms. The main results in this field for 2009 were:

- **Is the Kondo screening a must?** (E. Tosatti and M. Fabrizio)

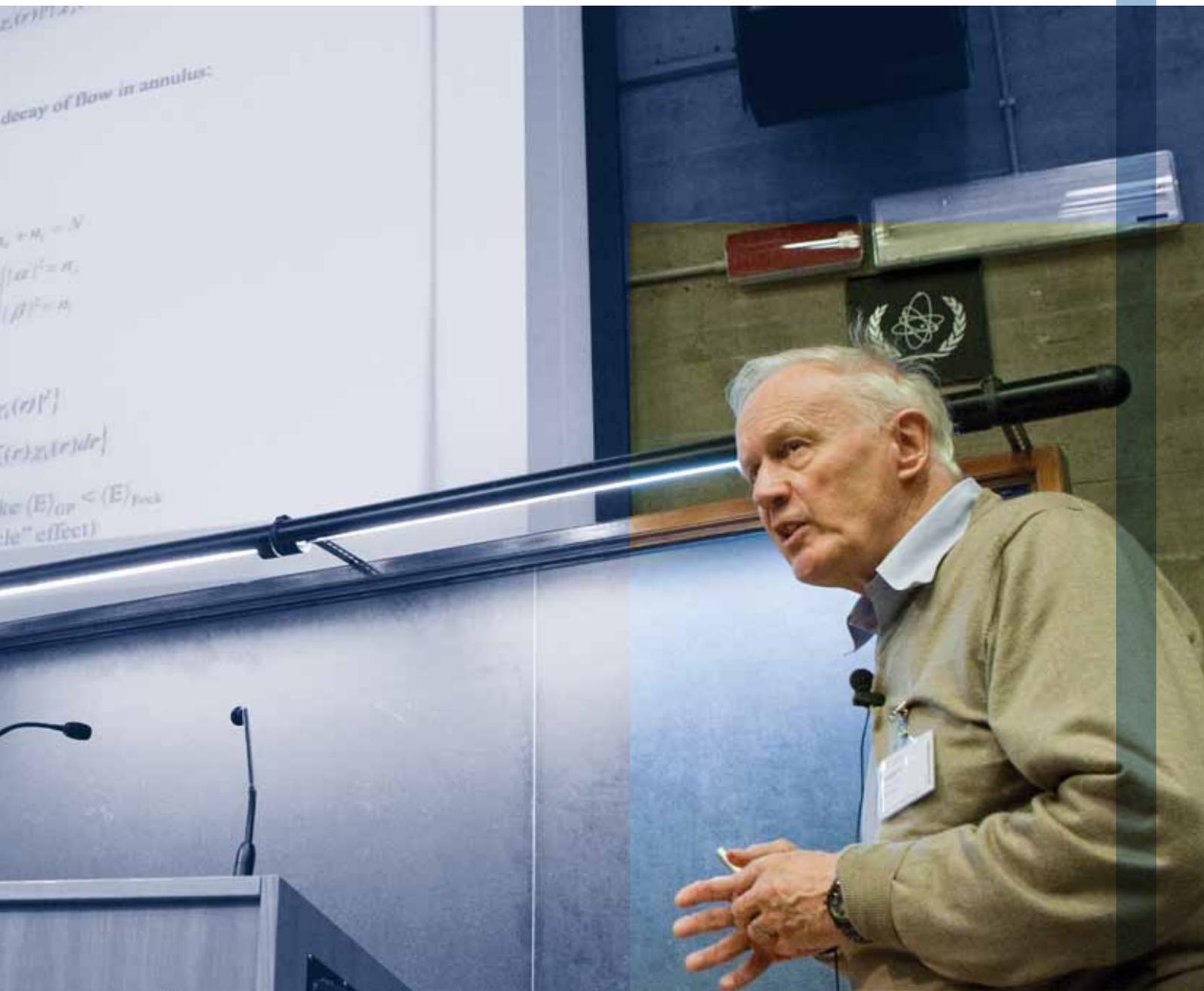
It is well known and commonly accepted that the Kondo effect leads to screening of the impurity spin by spinful conducting electrons, thereby removing the Curie divergence of magnetic susceptibility at temperatures below Kondo temperature. The new method that combines the ab-initio calculations with the numerical renormalization group approach of Wilson has been developed and applied to the case of nano-junctions of nearly ferromagnetic metals. It appeared that at certain conditions the ferromagnetic Kondo effect may arise in this system with numerous physical implications that are drastically different from those of the more common antiferromagnetic Kondo effect.

- **What is common in cold atoms, black hole physics and random matrices?** (V.E. Kravtsov and F. Franchini)

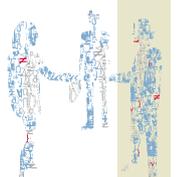
It is shown that correlation of eigenvalues in certain (unconventional) invariant random matrix ensembles (with log-normal probability measure) is similar to the density correlations of Hawking phonons in a sonic analogy of black holes in a flow of cold atoms. The sonic analogy of black holes in 1+1 space-time arises when the sound velocity in a quasi one-dimensional system of interacting cold atoms is set (by detuning interaction by magnetic field) smaller than the flow velocity in the half-space $x > 0$, while it is larger than the flow velocity for $x < 0$. The point $x = 0$ is analogous to an event horizon, with the entire region $x > 0$ representing the interior of a black hole, from where no phonon can escape. The random matrix-black hole analogy allows to predict oscillations in the density-density correlations of the sonic analogy of Hawking radiation and points out at the intimate relation between this random matrix theory, conformal field theory and geometry of the curved space-time with the event horizon (AdS-CFT analogy).

- **Bose glass: How many quantum phase transitions?** (M. Müller)

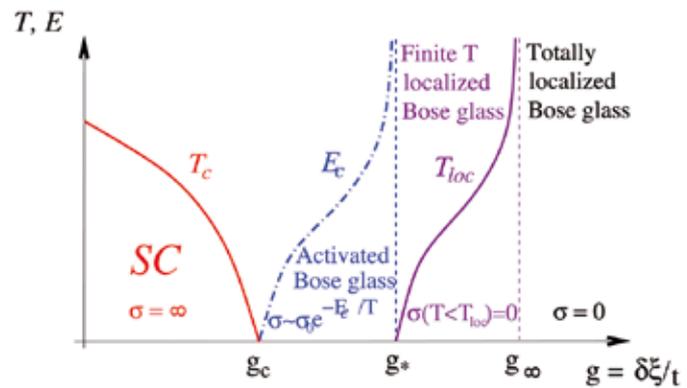
Superfluidity of cold bosons in disordered optical lattices and certain models of superconductivity in bad metals reduce to a problem of bosons in a disordered environment, so called Bose glass. The main problem here is: what does the disorder do to superfluidity and superconductivity of weakly interacted bosons and how many phases arise as the parameter (disorder strength)/



Nobel Laureate Anthony J. Leggett lecturing at Conference on Research Frontiers in Ultra-Cold Atoms, 4-8 May 2009



(interaction) increases at very low temperature? At very weak disorder the system is superfluid. At strong enough disorder it is predicted (B.L. Altshuler, D. Basko, I.L. Aleiner) to become a perfect insulator with the activation gap proportional to the volume. The question that is currently under vigorous discussion in the community is whether or not there is only one quantum critical point (g_c) that separates superfluid and the perfect insulator. According to the scenario suggested by M. Müller, in three-dimensional systems there is an intermediate imperfect insulating phase (and likely the second quantum critical point g^*) where the resistance at low temperatures is exponentially small; however, the activation energy is finite in the thermodynamic limit (activated Bose glass).

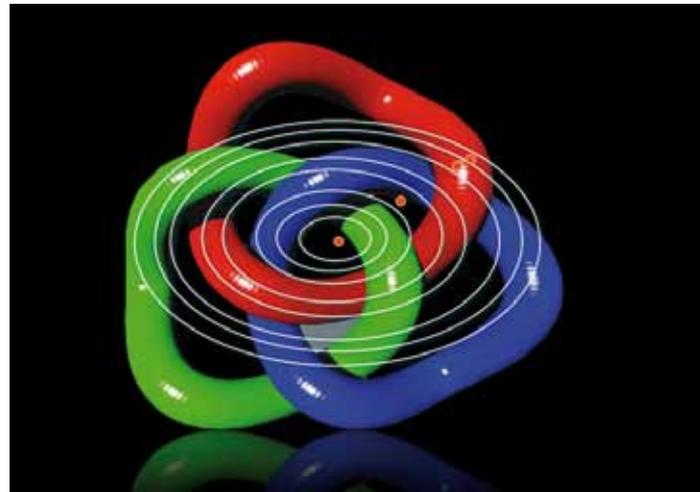


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Phase diagram
of the Bose glass

- **Fundamentals of hardware for quantum computations: Noise in a driven two-level system and topologically protected qubits in anyon quantum chains** (M.N. Kiselev, G. Mussardo)

Quantum computations and the corresponding read/write protocols imply an efficient time-dependent control of the quantum mechanical system. However, in many realizations of the quantum qubit (e.g., in a double quantum dot device used as a spin qubit) noise is inevitable (e.g., slow fluctuations of nuclear spins in a quantum dot) and it influences a lot the behavior of the system. In particular, such slow noise is shown to lead to a “blockade” of the qubit in a given state. The corresponding optimal read/write protocols to avoid such a blockade are formulated using the new representation of the solution to the Landau-Zener problem (M.N. Kiselev).

Another route to drastically reduce the effect of noise is to use topological quantum objects (which are not sensitive to small fluctuations in the same topological sector) in quantum computations. In particular, using a class of topological objects, the Fibonacci anyons, represented by a product of icosahedral group elements, could be a perspective direction in topologically protected quantum computations (G. Mussardo).



↑
Quantum Hall states
and braiding of anyons

[Statistical Mechanics and Applications

CMSP work in this area focussed on cooperative phenomena in complex adaptive systems, statistical mechanical descriptions of complex networks (such as the financial market), application of statistical mechanics to computer science, optimization problems in genetics and biophysics, non-equilibrium statistical mechanics, and quantum computing. The results have applications for computer network performance, financial markets and genetics, among other things.

- **The Nash equilibria: What the Game Theory may give to financial market stability** (L. Dall'Asta, M. Marsili, A. Ramenzapour, P. Pin)

The Game Theory is the mathematical tool for constructing and studying the general trends in self-organizing systems of interacting agents that are the simplified versions of a free market. One of the most important concepts of the Game Theory relevant for stability of a free market economy is the notion of the Nash equilibria, in particular its character, existence and statistics. The optimization version of this problem is known to be one of the most difficult NP-hard optimization problems in computer science. The onset and reason for such hardness is a subject of intense current research. Using the cavity approach, the authors were able to get the exact statistics of the Nash equilibria and to unveil the reason of the hardness as hidden in the structure of the solution-space of the problem.

- **Essential genes and the architecture of the protein folding networks: A view from new statistical methods of feature extraction** (M. Marsili)

One of the main puzzles in molecular biology is how genes which control reactions locally can determine the global architecture of the protein interaction network. The authors proposed a new statistical method based on the entropy of the randomized network ensembles, to estimate how much of a particular feature, defined on the nodes of a graph, is relevant for the architecture of the network. This has led to the identification of essential genes in particular biological functions. The study was published in *Proc. Nat. Acad. Sci. USA* (see full CMSP publications list on attached CD).

- **From classical to quantum computer science: Quantum satisfiability problem** (A. Scardicchio, S.L. Sondhi (Princeton), R. Mössner (Dresden))

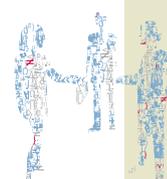
The classical satisfiability problem which has numerous applications, including finding the ground state of a classical spin system with complex (not pair) interactions, is one of the most fundamental problems in computer science. Of particular interest are the SAT/UNSAT transitions which indicate the onset of complexity and computational hardness. Its quantum analogue which is relevant for the emerging field of quantum computation, is currently of great interest. This work was aimed at identifying the parameter space in which hard problems for quantum computation may arise and at studying the behavior near the quantum SAT/UNSAT transitions. The behavior was shown to be characterized by a number of unusual features, including the metastability for negative temperatures.

- **Exact many-body correlation functions in the Lieb-Linger model: Application to one-dimensional systems of cold atoms** (G. Mussardo)

Based on the non-relativistic limit of the Sinh-Gordon model and Thermodynamic Bethe Ansatz, a method to obtain exact expression for many-body correlation functions in a one-dimensional quantum system with the Lieb-Linger Hamiltonian was developed. It has a broad range of applications in the systems of cold atoms.

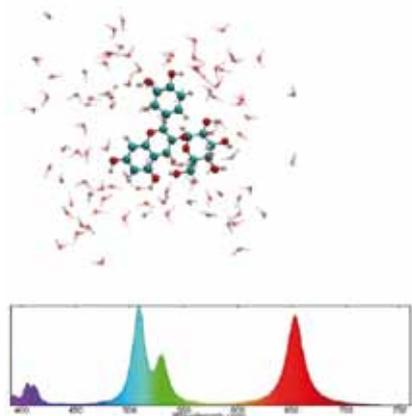
[Electronic Structure and Computer Simulations

CMSP work in this area focussed on simulations of condensed matter at high pressures, new materials, ab-initio calculations of properties of nano- and bio-systems, catalysis and surface



physics, simulations of fast processes of energy transfer, energy conversion and storage research, and physics of friction and lubrication.

- **“Quantum-Espresso” and its application to photovoltaic materials** (R. Gebauer, S. Scandolo)



Density-functional theory (DFT) is one of the most powerful methods of electronic structure computations. Unfortunately, it is literally applied only to the ground state. At the same time a growing demand from biology and energy production/transfer phenomena is a possibility to describe fast time-dependent processes, which require taking into account many excited states as well. This is in principle possible in the framework of the time-dependent DFT, however it is very expensive in terms of the computation time. A considerable methodological effort undertaken by an ICTP-SISSA team in which R. Gebauer and S. Scandolo took an active

part has lead to the development of a new recursive technique which reduces considerably the numerical complexity involved in time-dependent DFT and allows to compute optical properties in large (up to 500 atoms) systems. This technique, called “Quantum Espresso” opens the door to computations in biological systems and systems where the effect of the environment is significant. That is why it is rapidly gaining popularity in the community.

In particular, one of the possible applications is photovoltaic materials where an initial electronic excitation (by light) is followed by a fast separation of the thus generated electron-hole pairs.

- **Non-molecular phases of CO₂ at high pressure: The mysterious phase VI** (S. Scandolo, M.-S. Lee, E. Tosatti)

The recent discovery that molecular CO₂ transforms under compression into extended nonmolecular phases that are structurally similar to the ambient-pressure phases of silica opens unique scenarios on the solid-state chemistry of carbon oxides. In particular, the structural analogy of nonmolecular CO₂ with isoelectronic compounds SiO₂ and GeO₂ raises important questions regarding the tetrahedral or octahedral nature of the carbon coordination with oxygen. Metadynamics simulations starting from the molecular CO₂-II phase yielded, at 60 GPa, a fully tetrahedral, layered structure. Based on the agreement between calculated and experimental Raman and X-ray patterns, the recently identified phase VI was interpreted as the result of an incomplete transformation of the molecular phase into a final layered structure (J. Sun et al. 2009. *Proc Natl. Acad. Sci. USA* **106** 6077). Based on static calculations at higher pressure, it was showed that a similar layered structure with carbon in tetrahedral coordination is thermodynamically stable between 200 and 900 GPa. The Raman spectrum for this phase also agrees with that measured for CO₂-VI.



The flavylium (biological dye) molecule together with the surrounding solvent water. The bottom of the picture shows the calculated photoabsorption spectrum

+ Synchrotron Radiation Related Theory

Within the CMSP section, the Synchrotron Radiation Related Theory group performs theoretical research and training in areas of condensed matter physics that are experimentally investigated by synchrotron radiation (SR). There is close collaboration with experimentalists at the nearby SR source ELETTRA and at other similar facilities.

Within the relatively large scope of problems that fall under this description, the group has two main focusses of activities. The first field of activities is the investigation of the electronic, magnetic, and structural properties of systems with strong electron correlations, including transition-metal oxides and related materials. The second, more recent, area of interest is the physics of low-dimensional systems and nanostructures.

For more details on research achievements, please see ICTP's Full Technical Report on the attached CD.

+ CMSP Publication Highlights

Condensed Matter and Statistical Physics

Altshuler, B.L.; Kravtsov, V.E.; Lerner, I.V.; Aleiner, I.L. 2009. Jumps in current-voltage characteristics in disordered films. *Phys. Rev. Lett.* **102** 176803

Borghini, G.; Fabrizio, M.; Tosatti, E. 2009. Surface dead layer for quasiparticles near a Mott transition. *Phys. Rev. Lett.* **102** 066806

Giannozzi, P.; Baroni, S.; Gebauer R.; Scandolo, S.; Smogunov, A. et al. 2009. QUANTUM ESPRESSO: a modular and open-source software project for quantum simulations of materials. *J. Phys.: Condens. Matter* **21** 395502

Müller, M.; Schmalian, J.; Fritz, L. 2009. Graphene—a nearly perfect liquid. *Phys. Rev. Lett.* **103** 025301.

Rossini, E.; Silva, A.; Mussardo, G.; Santoro, G. 2009. Effective thermal dynamics following a quantum quench in a spin chain. *Phys. Rev. Lett.* **102** 127204

Zhang, X.H.; Santoro, G.E.; Tartaglino, U.; Tosatti, E. 2009. Dynamical chiral symmetry breaking in sliding nanotubes. *Phys. Rev. Lett.* **102** 125502

Synchrotron Radiation Related Theory

Aballe, L.; Barinov, A.; Stojic, N.; Binggeli, N.; Menten, T.O.; Locatelli, A.; Kiskinova, M. 2010. The electron density decay length effect on surface reactivity. *J. Phys.: Condens. Matter*. **22** 015001

Zheng, B.; Binggeli, N. 2009. Effects of chemical order and atomic relaxation on the electronic and magnetic properties of $\text{La}_{2/3}\text{Sr}_{1/3}\text{MnO}_3$. *J. Phys.: Condens. Matter* **21** 115602-1/9



ICTP's Mathematics section is mainly oriented towards geometry and analysis. It has played an important role in fostering mathematics research and education in developing countries.

Research themes for 2009 were p -adic analysis and low-dimensional topology. In keeping with this, a major school/conference was organized in each field (on p -adic analysis and knot theory respectively). The other major activities focussed on advanced linear algebra and integrable systems. A highlight of the research was the proof (by Göttsche and collaborators) of the Witten conjecture relating Donaldson and Seiberg–Witten invariants (in the case of algebraic surfaces).

Staff members worked on the following topics during 2009:

C.E. Chidume: Continued work on approximations to solutions of nonlinear equations defined on Banach spaces.

L. Göttsche: Continued his work on the generating functions of sections of line bundles on moduli spaces of sheaves on surfaces.

D.T. Lê: Together with D. Cheniot (University of Provence, France), was engaged in a study of S. Lefschetz' proof of the Hard Lefschetz Theorem, in an attempt to overcome the (known) problems in this purely topological approach to a cornerstone of algebraic geometry. In joint work with G. Barsegian (Institute of Mathematics, National Academy of Sciences of Armenia), obtained an estimate of the length of level sets of a real polynomial in two variables. This finds application to a conjecture by Erdős.

J. Li: Studied symplectic critical surfaces in a Kähler surface, and the energy identity during blowing up for approximation harmonic maps.

S. Luzzatto: Continued to investigate the relation between the geometric structure of dynamical systems and their ergodic properties. In joint work with P. Pilarczyk (University of Minho, Portugal), laid the foundations for a rigorous approach to computer-assisted proofs in the field.

R.T. Ramakrishnan: Continued to work on Hodge conjecture for abelian four-folds and the unitarity of the Hitchin connection.

Staff Associates worked on the following:

O.A. Laudal: Continued the study of models—using non-commutative algebraic geometry—for quantum physics.

J. Seade Kuri: Research was primarily concerned with the topology of real and complex singularities. Continued work on foliations with Bott–Morse singularities and on discrete groups acting on complex projective spaces.

+ Post-doctoral fellows and visitors

The post-doctoral fellows and visitors in the section represent a wide variety of interests and come from around the world. The section has always made a particular effort to promote diversity, while at the same time striving to maintain a vibrant research community.



Advanced School and Conference on Knot Theory and its Applications
to Physics and Biology, 11-29 May 2009



In 2009, Mathematics' post-doctoral fellows worked on Frobenius manifolds (Yassir Dinar, Sudan), hyperplane arrangements, braid groups and dynamical systems (Shaheen Nazir, Pakistan), contact and symplectic geometry (Dishant Pancholi, India) moduli problems on algebraic surfaces (R. Parthasarathi, India), dynamical systems and planar Jacobian maps (Roland Rabanal, Peru), Nevanlinna theory (Van Tan Tran, Vietnam), nonlinear elliptic equations (Akila Yechoui, Algeria), harmonic maps and the Skyrme model (Xiangrong Zhu, China).



Other visitors studied Khovanov cohomology (Ahmad Zainy Al-Yasry, Iraq), mean field equations (Meng Wang, China), spectral theory (M. Boumazgour, Morocco), Suslin matrices (Selby Jose Nalleparambil, India), rational points on elliptic curves (Carlos Castaño-Bernard, Mexico), functional differential equations (Mohammed Abdalla Darwish, Egypt), Hardy inequalities (Alnar L. Detalla, Philippines), quivers (Hua-Lin Huang, China), and spectral theory of operators on Fock space (Tulkin H. Rasulov, Uzbekistan).


Lothar Göttsche
awarding the Diploma in
Mathematics to Azizeh
Nozad, 21 August 2009

The year 2009 was one of transition for the Mathematics section, as it saw the retirement of section head Lê Dung Tráng. Another section mathematician, Charles Chidume, also retired and is now acting president of the African University of Science and Technology; Li Jiayu left to rejoin the Institute of Mathematics, Academy of Mathematics and Systems Science, Beijing. In April, Stefano Luzzatto from Imperial College, London, arrived. Luzzatto works in ergodic properties of dynamical systems, and is also interested in the use of computer-assisted proofs in the field.

The section continued its active involvement in Africa: in Nigeria with the Sub-Saharan PhD Programme, and in East Africa with the East African Universities Mathematics Programme. It also helped to organize a conference in Gharian, Libya.

The Mathematics section hosted 114 visitors from 47 countries (among them were 25 mathematicians from 13 African countries). These visits resulted in 32 seminars and 32 publications in 2009.

+ Mathematics Publication Highlights

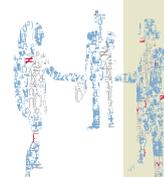
Araujo, V.; Luzzatto, S.; Viana, M. 2009. Invariant measures for interval maps with critical points and singularities. *Advances in Mathematics* **221**, no. 5, 1428-1444

Göttsche, L.; Nakajima, H.; Yoshioka, K. 2009. K-theoretic Donaldson invariants via instanton counting. *Pure Appl. Math. Q.* **5** 1029-1111

Li, J.; Wang, M. 2009. Liouville theorems for self-similar solutions of heat flows. *J. Eur. Math. Soc. (JEMS)* **11** 207-221

Scárdua, B.; Seade, J. 2009. Codimension one foliations with Bott-Morse singularities I. *J. Differ. Geom.* **83** 189-212

T.R. Ramadas. 2009. The “Harder-Narasimhan trace” and unitarity of the KZ/Hitchin connection: genus 0. *Ann. of Math.* **2** **169** 1-39



ICTP's Earth System Physics (ESP) section studies a wide spectrum of the Earth system, from its fluid components (oceans and the atmosphere) to the planet's interior. Two main research lines are conducted in fluid Earth physics: Climate Change and Impacts (CCI) and Natural Climate Variability and Predictability (NCVP). Within the solid Earth physics area the main line of research is in Mechanics of Earthquakes and Tectonophysics (MET). ESP also includes the Structure and Non-Linear Dynamics of the Earth (SAND) group as a hosted activity.

The ESP section maintains a range of models and datasets and coordinates the Regional Climate research NETWORK (RegCNET), encompassing over 600 participants worldwide. Finally, unlike other ICTP sections, ESP obtains a sizeable amount of funding from external research grants (for example the EU).

[Climate Change and Impacts (CCI)

The CCI research line aims at improving the understanding of anthropogenic climate change and its impacts on human societies and natural ecosystems.

During 2009, ESP continued to develop, test and apply its regional climate model, RegCM, which is maintained for use by a wide community of scientists. In particular, the section started developing a new version of the model (RegCM4), which they plan to release during the fifth ICTP regional modelling workshop in June 2010 and which will place ESP at the forefront of regional climate modelling.

Other climate-change related activities included ESP's participation in the COordinated regional climate Downscaling EXperiment (CORDEX), a new international initiative promoted by the World Climate Research Programme (WCRP). ESP staff members have played an active and central role in the design and implementation of the CORDEX initiative. The RegCM model will participate to this program through the involvement of different scientists from developing countries involved in the ICTP RegCNET network.

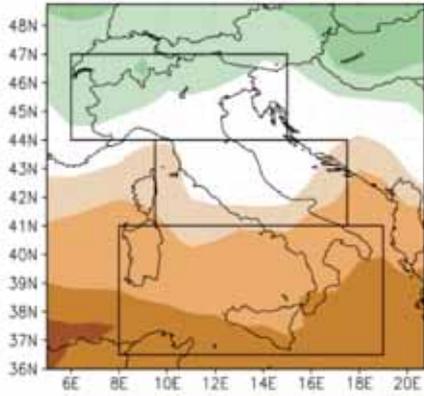
ESP also collaborated with various institutes outside ICTP, and as part of different European projects (ENSEMBLES, AMMA, ACQWA, WATCH), to perform multi-decadal, high-resolution climate change simulations for Europe, Africa and East Asia. In one such study, high resolution runs (15 km grid spacing) were completed over the Alpine/central Mediterranean region using the so called "surrogate climate change" approach and a version of the model employing a sub-grid land surface scheme reaching a resolution of 3 km (Im et al., GRL, in press). This study led to the discovery of a new local feedback mechanism by which decreased spring snow cover and soil moisture due to greenhouse gas warming leads to reduced summer precipitation over mountainous areas.

ESP's comprehensive assessment of climate change projections over the Italian peninsula represents the only such assessment for Italy.

ESP completed extensive work in the area of chemistry-climate coupling towards the development of a RegCM-CHEM coupled system. This makes the RegCM system the most advanced and versatile in the world in terms of chemistry coupling for air quality and climate applications.

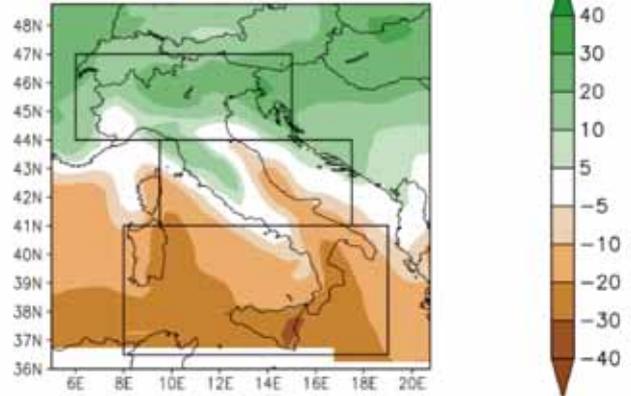
In 2009, ESP greatly expanded its research on climate impacts on hydrology, agriculture and

PREC change A2 % (DJF)



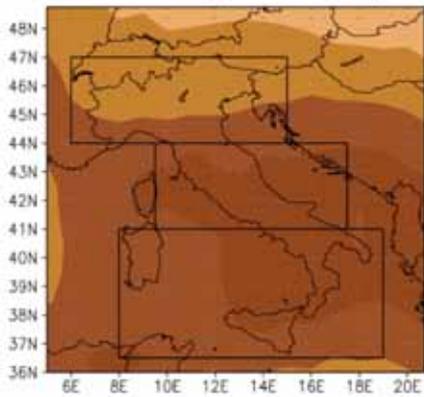
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precip change A2 % (DJF)



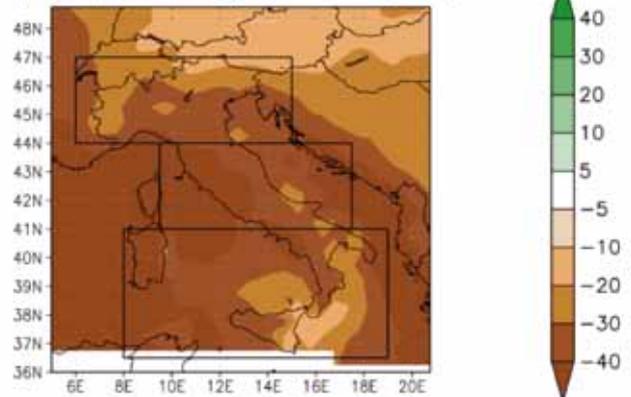
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PREC change A2 % (JJA)



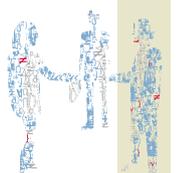
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precip change A2 % (JJA)



d

↑
Simulated change in precipitation over Italy for 2071-2100 compared to 1961-1990 for the A2 greenhouse gas emission scenario in winter (DJF, upper panels) and summer (JJA, lower panels) for the CMIP3 ensemble of global model simulations (left panels) and the PRUDENCE ensemble of regional model simulations (right panels). Units are % of present day precipitation



health. The hydrology model CHYM was interfaced with RegCM and is currently used within ESP for a variety of applications. ESP's acquisition of the crop model GLAM in 2009 will provide an important resource to study the interactions between climate and crop productivity in different contexts. Climate variability can also influence health through its impact on the spread of vector-borne diseases. ESP successfully co-led a €3 million European Union proposal to produce monthly and seasonal predictions of malaria and rift valley fever for Senegal, Ghana and Malawi using leading forecast models to drive dynamical disease models.

[Natural Climate Variability and Predictability (NCVP)

South Asian Climate
Outlook Forum (Inception
Meeting), 6 August

The NCVP research line focusses on natural climate variability and predictability at temporal scales from intra-seasonal and seasonal to multi-year and multi-decadal.

ESP's examination of the intra-seasonal variability of south Asian monsoon rainfall showed that the El Niño-Southern Oscillation (ENSO) influences high-frequency rainfall variability in a nonlinear manner, and that there is a seasonally persisting pattern only during the El Niño period.

Other phenomena studied under the NCVP theme included predictability of the African monsoon, and in particular the origin of systematic model biases in reproducing the evolution of the Tropical Rain Band, and the interannual variability of the tropical ocean-atmosphere system.

[Mechanics of Earthquakes and Tectonophysics (MET)

The MET research line investigates the way earthquake faults develop over time and how the Earth's interior deforms, with emphasis on the physics of crust-upper mantle interactions.

In 2009, MET focussed on three research projects:

- Time-variable gravity—hydrology vs. solid-Earth processes: Using data taken from space gravity missions that measures mass redistribution within the Earth and at its surface, MET has shown that mass changes cannot be classified simply as trends or periodic signals. The group proposed an alternative way to discriminate signals from different possible sources mostly in the low latitude regions, such as Africa, where the hydrological cycle is most intense.
- An impending earthquake visible in GPS data and the missed LAquila earthquake forecasting: This study reported on a clear acceleration in rates of deformation from available, continuous GPS data prior to the April 2009 LAquila earthquake. The GPS data,



by complementing the localized anomalous increase in the seismicity around LAquila as well as the changes in radon concentration, could have been decisive for an operational earthquake forecast.

- Earth structure across Afar (northern Ethiopia) from surface wave tomography: In the remote Afar depression of northern Ethiopia, the African continent is slowly splitting apart and a new ocean is forming. MET has created tomographic maps of the region; the next step will be to provide shear wave velocity models and therefore a better description of the Afar crust.

+ ESP Publication Highlights

Borghi, A.; Aoudia, A.; Riva, R.E.M.; Barzaghi, R. 2009. GPS monitoring and earthquake prediction: a success story towards a useful integration. *Tectonophysics* **465** 177-189

Coppola, E.; Giorgi, F. 2010. An assessment of temperature and precipitation change projections over Italy from recent global and regional climate model simulations. *International Journal of Climatology* **30** 11-32

Kucharski F. et al. 2009. The CLIVAR C20C Project: skill of simulating Indian monsoon rainfall on interannual to decadal timescale. Does GHG forcing play a role? *Climate Dynamics* **33** 615-627

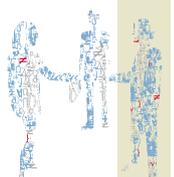
Tompkins, A.M.; Feudale, L. Seasonal ensemble predictions of West African monsoon precipitation in the ECMWF system 3 with a focus on the AMMA special observing period in 2006. *Weather and Forecasting, Special AMMA Issue*, doi:10.1175/2009WAF2222236.1

[Structure and Non-Linear Dynamics of the Earth (SAND)

The aim of the SAND group is to understand the physics of the solid Earth, including earthquake sources and predictions, by modelling wave propagation and the non-linear dynamics of the lithosphere. The research activities are divided into two main lines: Non-Linear Dynamics of the Earth's Lithosphere, with the goal of earthquake prediction; and Structure of the Earth with Application to Seismic and Volcanic Risk Mitigation (based on 3-D modelling of the Earth's structure and earthquake sources).

The activities in 2009 within the framework of the first line spanned from numerical modelling of lithosphere dynamics to prediction of extreme events in complex systems and earthquake prediction studies.

Within the framework of the second line, SAND performed seismic source studies, tsunami and ground motion modelling, and studies on carbon cycling into the upper mantle and into the exosphere. They discovered a global asymmetry across oceanic ridges showing that the lithosphere in the western side of the rift is faster than in the eastern or north-eastern side. SAND also found that in plate tectonics, the classic mantle convection is complemented and polarized by the steady-state torque provided by the tidal bulge misalignment. In addition, they developed



fully formalized and automatic procedures for the routine updating of the intermediate-term, middle-range earthquake predictions, as well as of the related time-dependent scenarios of ground motion, for Italy and its surroundings.

+ SAND Publication Highlights

Frezzotti, M.L.; Peccerillo, A.; **Panza, G.F.** 2009. Carbonate metasomatism and CO₂ lithosphere-asthenosphere degassing beneath the Western Mediterranean: an integrated model arising from petrological and geophysical data. *Chemical Geology* **262** 108-120

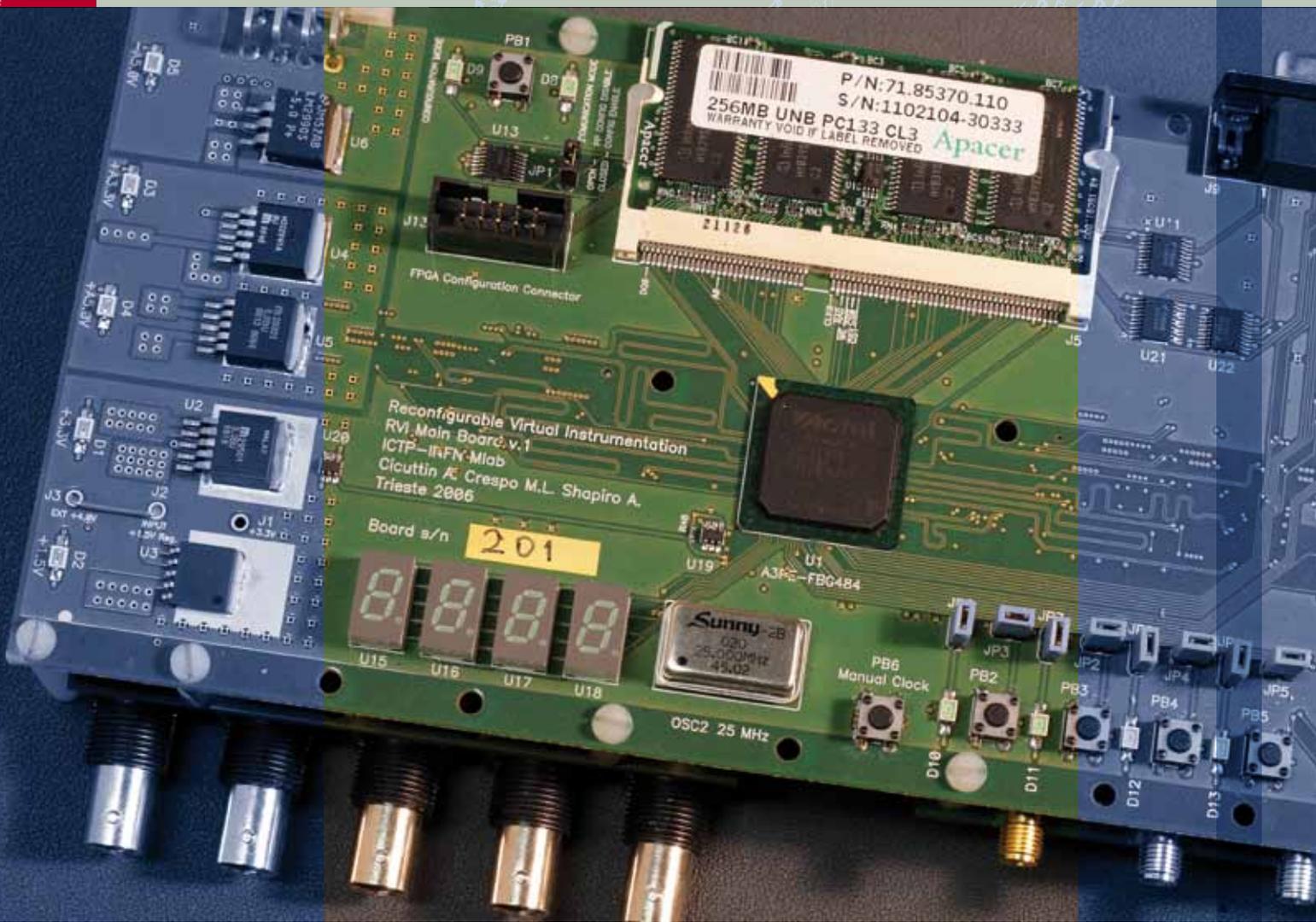
Harbi, A.; Peresan, A.; Panza, G.F. 2009. Seismicity of Eastern Algeria: ECEA the revised and extended earthquake catalogue. *Natural Hazards* doi:10.1007/s11069-009-9497-6

Keilis-Borok, V.; Soloviev, A.; Lichtman, A. 2009. Extreme events in socio-economic and political complex systems, predictability of. Meyers R. (ed.) *Encyclopedia of Complexity and Systems Science*, Springer, New York, 3300-3317

Narteau, C.; Byrdina, S.; Shebalin, P.; Schorlemmer, D. 2009. Common dependence on stress for the two fundamental laws of statistical seismology. *Nature*, **462**, 7273, pp. 642-645

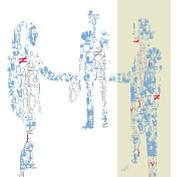
2.5

Applied Physics



ICTP's diverse Applied Physics section encompasses areas of research that respond to the most critical needs of the ICTP scientific community. The areas are, in fact, among the activities for which the demand in developing countries is enormous and growing, and ones that make more direct contact with the outside world.

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ICTP-RVI motherboard, a high-performance hardware platform for reconfigurable virtual instrumentation based on FPGA technology



[Aeronomy and Radiopropagation

Scientists at ICTP's Aeronomy and Radiopropagation Laboratory (ARPL) study electron density in the ionosphere to determine ionospheric effects on satellite navigation and positioning using GPS, the augmentation systems developed or being developed in the USA, Europe, Japan, China and India and other areas of the world, and the future European GALILEO system.

In 2009, ICTP signed an agreement with Boston College to promote satellite navigation science and technology activities in Africa through training activities and research projects. A series of collaborations have started with scientific groups in African universities towards the implementation of joint research activities in this field.

Aeronomy research activities in 2009 focussed on ionospheric model studies, the detection of electron density depletions, and radio occultation studies. The European Space Agency (ESA) has requested ARPL to adapt its ionospheric NeQuick 2 model, based on the version originally developed with the University of Graz (Austria), to the International Telecommunications Union (ITU) requirements to be introduced in ITU Radiocommunications Sector's recommendations. A series of model tests and verifications, as well as software and technical documentation, will be done under contract with ESA.

Activities in information technology and radiocommunications-related topics covered in-house training and capacity building and on-site activities linked to the use of radio systems in information and communication technologies for developing countries. Activities included an ongoing collaboration with Consorzio Venezia Nuova to develop and test wireless systems using Wi-Fi technologies for environmental monitoring. With financial support from the Consorzio, ARPL deployed a low-cost wireless mesh network that provides Internet connectivity for water sensors in the Venice lagoon. During March and April 2009, ARPL deployed a network of Wi-Fi and WiMAX systems in the Venice lagoon to test the possibilities of installing similar networks in developing countries for water management monitoring.

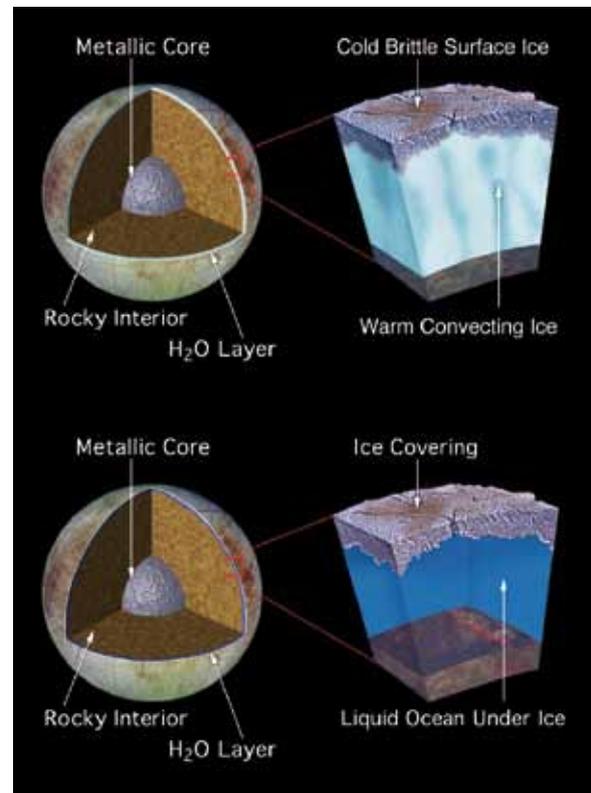
ARPL designed and deployed a wireless sensor network to monitor water quality in Malawi, where poor water quality has been a major cause of mortality, especially for children under five years of age.

ARPL is active in providing ICT and satellite training programmes in developing countries. For details on its training programmes in Africa, see the "Training and Education" section of this report.

[Biosciences

Bioastronomy is the study of the origin, evolution, distribution and destiny of life in the universe. In 2009, ICTP research in this area focussed on suggesting experiments that are possible, not only with present technology, but also within the space agencies' budgets, to explore the

Model of Europa's
subsurface structure
(Courtesy: NASA/JPL)



Jovian satellite Europa. Related to those experiments is the development of planetary micro-penetrators suitable for the exploration of Europa's icy surface. Research at ICTP focussed on the type of instruments that the penetrators should be provided with to help search for life signatures.

[Fluid Dynamics

The ICTP Fluid Dynamics Laboratory is a world-class research facility whose activities range from quantum to classical fluid flows and whose centrepiece is an apparatus capable of producing the highest levels of controlled buoyancy-driven turbulence in the world. It operates at a temperature of near-absolute zero and provides high-resolution data at the far frontier of fluid dynamics.

From its position atop a rotating platform, ICTP's turbulent convection experiment provides data applicable to large-scale natural phenomena like atmospheric and solar convection in a range of control parameters not possible elsewhere. Recent experiments have taken particular advantage of the possibility to apply more realistic boundary conditions, particularly the more two-dimensional aspect ratios characteristic of natural extended systems. Novel techniques involving the propagation of high frequency thermal waves have made it possible to provide the first direct mapping of a thermally "superconducting" core at high turbulent intensities, which has been one of the key assumptions in phenomenological theories of turbulent convection.

[Optics and Lasers

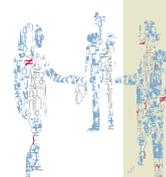
In 2009, ICTP and SPIE, the international optics and photonics society, started a new research initiative on quantum cascade lasers (QCL), which have numerous applications in the remote sensing of environmental gases and pollutants, as well as in medical diagnostics.

The QCL research is being carried out in collaboration with the Istituto Nazionale di Fisica Nucleare (INFN).

[Multidisciplinary Laboratory

The ICTP MLab promotes interdisciplinary experimental activities based on advanced instruments and methods developed in basic physics research. The aim of this programme is to stimulate synergic cooperation with other research laboratories in the Trieste area as well as at national and international levels.

MLab activities include scientific instrumentation development, novel detector and electronic circuit design and prototyping, X-ray imaging and accelerator-based analytical techniques. The goal is also to involve visiting scientists and PhD students from developing countries in hands-on activities. ICTP's MLab comprises the following projects.



+ ICTP-INFN Microprocessor Laboratory

Microprocessors and microelectronics have brought about a revolution in computer science, manufacturing, and telecommunications, as well as in space and high-energy physics. To ensure that scientists from developing countries have access to this technology, ICTP, in collaboration with the Italian National Institute of Nuclear Physics (INFN), and other partners such as CERN and Actel Corp., offers courses on microelectronics and their applications in physics and experimental research. The Microprocessor Laboratory has cutting-edge technological alternatives for the design of instrumentation, including classical board-level design using microprocessors and programmable hardware logic devices, and the design of application-specific integrated circuits.

In 2009, the Microprocessor Laboratory continued its participation in the CERN COMPASS collaboration, as well as with Actel Corp., with which the Lab developed novel architectures for the implementation of Reconfigurable Virtual Instrumentation (RVI) systems using programmable logic devices. These low-cost, reusable hardware and software platforms can be used to build multiple electronic and scientific instrumentation systems. Twenty-three modular platforms were produced and used in the “Advanced Training Course on FPGA Design and VHDL for Hardware Simulation and Synthesis” held at ICTP in November 2009. The Lab also collaborated with INFN and the Istituto Nazionale di Astrofisica (INAF) on a project that aims to produce a large-area detector for low-energy X-ray measurements.

As a valuable complement to its core microelectronics training activities, the Lab continued its hardware loan programme for teachers and researchers from developing countries to borrow various advanced hardware platforms for research and educational applications, and for development of open source intellectual property.

+ Plasma-Focus Laboratory

The Plasma-Focus Laboratory explores applications in materials, medical and plasma sciences using a plasma-focus device, a relatively inexpensive, non-radioactive, compact, and efficient source of plasma and radiation. The Dense-Plasma-Focus device (DPF) applications include characterization of nanotechnology materials; dynamical defectoscopy of fast moving or rotating objects (such as tyres and airplane turbines), materials testing, explosives and other illicit materials detection, and production of isotopes for medical diagnosis and cancer therapy.

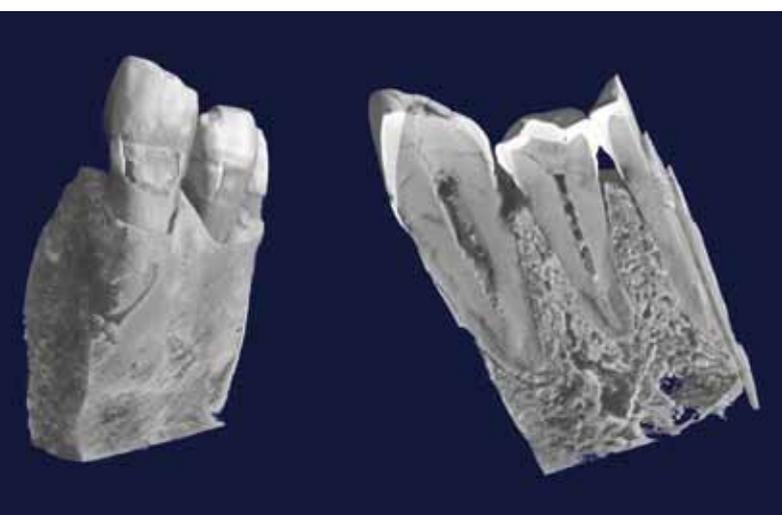
The official authorization to carry out experimental research activities with X-rays and neutrons at the MLab was obtained from local authorities, and the first official verification of the experimental setup was successfully completed in summer 2009. Also, the MLab plasma-focus device was equipped with detectors donated by the Institute of Plasma Physics and Laser Microfusion (IPPLM), Warsaw, Poland and the Moscow Physical Society (MPS) to measure absolute neutron and X-ray yields.

Claudio Tuniz
and Vladimir Gribkov
beside ICTP's plasma
focus device



+ X-ray Imaging Laboratory

The Imaging Laboratory uses X-rays to study artefacts, and also offers non-destructive analysis methods for disciplines ranging from material sciences to geology. With recent funding from the local government of Regione Friuli Venezia Giulia, the Laboratory is developing a compact portable device based on X-ray fluorescence for the in-situ, non-destructive, chemical characterization of a wide range of materials of interest to cultural heritage.



Other research activity in collaboration with the ELETTRA Synchrotron Light Laboratory and supported by the Regione involved the design and development of an X-ray microtomography system to characterize palaeontological and archaeological materials. The equipment was used to analyze one of the most important palaeoanthropological remains kept in the Trieste Natural History Museum, a human jaw discovered at the beginning of last century in a cave in Loke, Slovenia. The analysis discovered a cavity on the

upper surface of a worn tooth that probably had been intentionally cured by inserting an organic substance (a natural resin). To verify this hypothesis other analyses have been planned and a small sample has been taken to date the fossil.

+ Accelerator Mass Spectrometry

Accelerator Mass Spectrometry (AMS) is an analytical technique that measures carbon-14 and long-lived radionuclides to give accurate dates for archaeology and cultural heritage studies; AMS is also widely used in biomedical research. By collaborating with Italy's top AMS facilities in Caserta, ICTP provides access for scientists from developing countries to use advanced equipment that cannot be found in their home countries.

As an example of promoting the use of advanced physics tools by scientists from developing countries, ICTP supported a visiting scientist from Ghana who undertook training and practical research work in radiocarbon dating of archaeological samples using AMS, with the aim of analyzing charcoal samples from Iron Age sites in Ghana (Upper Volta region). Practical and theoretical knowledge gained through this project will help in the training and development of new students interested in this field as Ghana awaits the installation of its first accelerator at the Ghana Atomic Energy Commission.



3D rendering and
virtual longitudinal cut
of the Loke jaw
(Courtesy: MLab)



+ Applied Physics Publication Highlights

ARPL

Adeniyi, J.O.; Oladipo, O.A.; **Radicella, S.M.**; Adimula, I.A.; Olawepo, A.O. 2009. Analysis on 29 March 2006 eclipse effect on the ionosphere over Ilorin, Nigeria. *J. Geophys. Res.* **114** A11303 doi:10.1029/2009JA014416

Bagula, A.; Inggis, G.; Scott S.; **Zennaro, M.** On the relevance of using open wireless sensor networks in environment monitoring. *Sensors Journal* **6** 4845-4868

Coisson, P.; **Nava, B.**; **Radicella, S.M.** 2009. On the use of NeQuick topside option in IRI-2007. *Advances in Space Research* **43** 1688-1693

Migoya-Oru , Y.O.; **Radicella, S.M.**; P. Coisson. 2009. Low latitude ionospheric effects of major geomagnetic storms observed using TOPEX TEC data. *Ann. Geophys.* **27** 3133-3139

Biosciences

Chela-Flores, J. 2009. *A second genesis: stepping-stones towards the intelligibility of nature*. World Scientific Publishers, Singapore, 248 pp.
<http://www.ictp.it/~chelaf/ss220.html>

Chela-Flores, J. 2010a. Instrumentation for the search of habitable ecosystems in the future exploration of Europa and Ganymede. *International Journal of Astrobiology* **9** (2) 101-108 (Copyright holder: Cambridge University Press: 2010)
http://www.ictp.it/~chelaf/jcf_IJA_2010.pdf

Chela-Flores, J. 2010b. From the Moon to the moons: Encedalus and Europa. The search for life and reliable biomarkers. *Journal of Cosmology* **5** 971-981
<http://journalofcosmology.com/SearchForLife110.html>

Messerotti, M.; **Chela-Flores, J.** 2009. Solar activity and life. A review. *Acta Geophysica* **57** 64-74
<http://www.ictp.it/~chelaf/MesserottiJCF.pdf>

MLab

Alekseev, M.; ... **Cicuttin, A.**; **Crespo, M.L.**; ... et al. [COMPASS Collaboration]. *Gluon polarisation in the nucleon and longitudinal double spin asymmetries from open charm muon production*. *Physics Letters B* **676**, Issues 1-3, 1 June 2009, 31-38

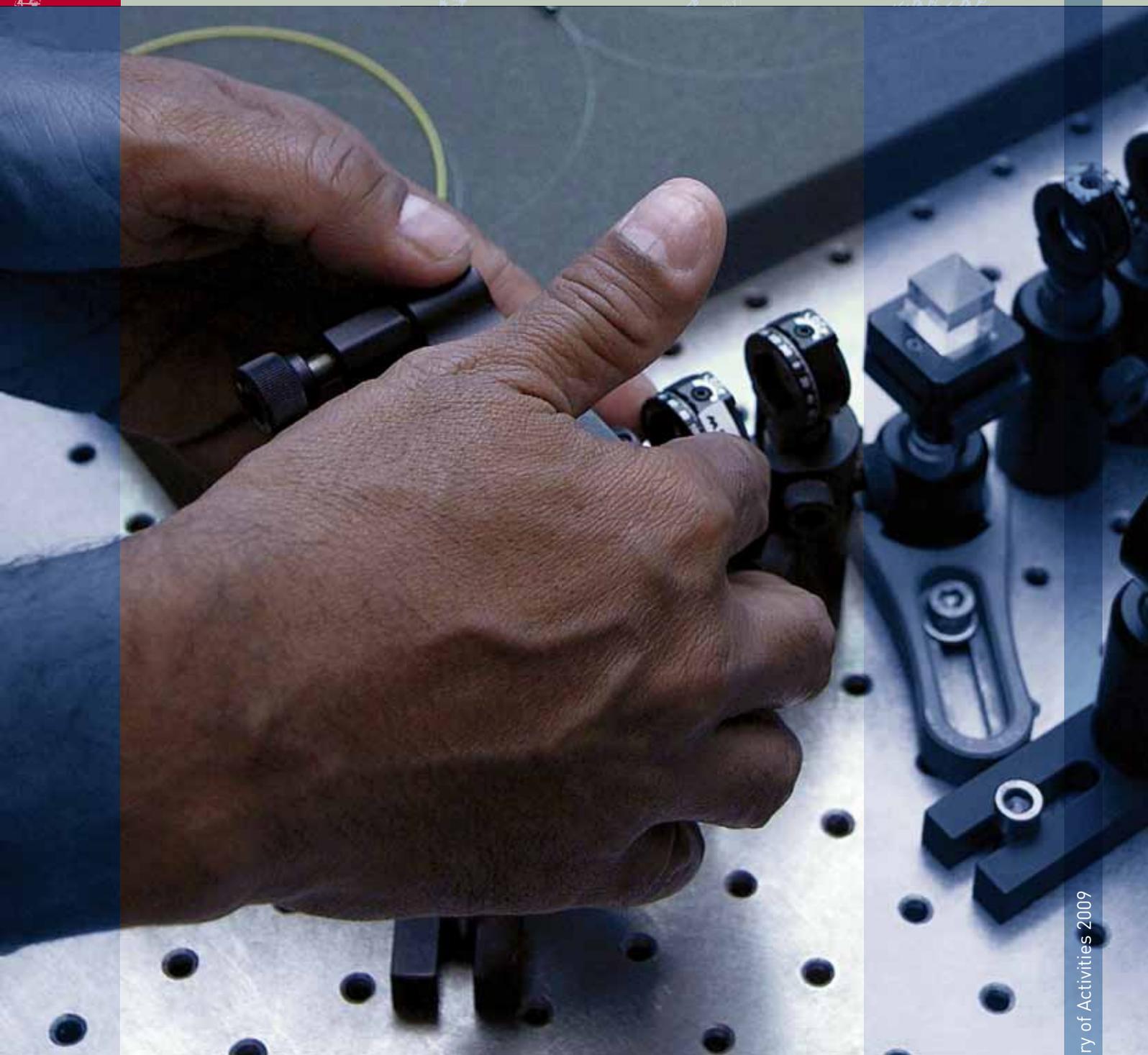
Alekseev, M.; ... **Cicuttin, A.**; **Crespo, M.L.**; ... et al. [COMPASS Collaboration]. *Flavour separation of helicity distributions from deep inelastic muon-deuteron scattering*. *Physics Letters B* **680**, Issue 3, 28 September 2009, 217-224

Chela-Flores, J.; Montenegro, M.E.; Pugliese, N.; Tewari, V.C.; **Tuniz, C.** 2010. Evolution of plant-animal interactions. Z. Dubinsky, J. Seckbach (eds.) *All flesh is grass: plant-animal interactions, a love-hate affair*. "Cellular Origins, Life in Extreme Habitats and Astrobiology" (COLE), Springer, Dordrecht, The Netherlands

Tuniz, C.; Gillespie, R.; Jones, Ch. 2009. *The bone readers: atoms, genes and the politics of Australia's deep past*. Crows Nest, N.S.W.; Allen & Unwin, Australia; Left Coast Press, USA; Springer, Italy

3.0

Training and Education Programmes



ICTP provides scientists from developing countries with the continuing training and skills that they need to enjoy long and productive careers. By providing these scientists with on-going opportunities for research and learning, ICTP has been a major force in reducing the scientific brain drain.

Scientists from developing countries have many different options when it comes to participating in ICTP's training and education activities. They can attend one of the more than 60 annual, short-term schools, conferences and workshops held in Trieste or in locations throughout the developing world. Workshop subjects range from elementary particle physics to cosmology, condensed matter physics to material science, mathematics to computational physics, and geophysics to climatology. A full list of ICTP's 2009 scientific conferences and workshops can be found on the accompanying CD.

ICTP offers longer-term training and research opportunities for scientists from developing countries through its various established educational programmes. These are described in the following sections.

3.0
PAGE 40

ICTP Training and Education Programmes									
No. of visits by region of origin									
Training and Education at ICTP	LDCs		Developing Regions			Transition Countries	CIS		TOTAL
	Africa	Asia	Africa	Asia	Latin America	Europe	Asia	Europe	
PhD Level									
Diploma Programme	15	4	14	12	3	—	1	—	49
ICTP-IAEA STEP Programme	5	—	22	6	2	1	—	4	40
Laurea Magistralis (w/Univ. Trieste)	3	—	1	3	—	—	—	—	7
Science Career Support									
Associate Scheme	11	5	54	65	37	9	16	9	206
Elettra Users Programme	—	24	1	—	10	—	—	1	36
Federation Scheme	—	—	15	26	24	8	—	3	76
TRIL Programme	—	11	—	86	—	—	7	3	107
TRIL for Africa	11	—	10	—	—	—	—	—	21

3.1 Training and Education at ICTP: PhD Level

+ Diploma Programme

The ICTP Diploma Programme is a gateway for young people who might otherwise not have a chance to reach international-level standards in physics and mathematics. Its goal is to take good students from the least-developed countries and train them so they can compete favourably for graduate studies in any centre of learning in the world. It consists of a rigorous, one-year, pre-doctoral course of study, with a small part devoted to independent projects. Areas of instruction include high-energy physics, condensed matter physics, mathematics, Earth system physics, and basic physics. After completing the Diploma Programme, most students go on to PhD work in Europe or North America. Others return to jobs as college teachers, or register for PhD programmes in their home countries.

During the 2008-09 study term, 49 students from 23 countries participated in the Diploma Programme. The PhD placements for those who received diplomas included:

Belgium	Katholieke Universiteit Leuven
Canada	Queens University, Kingston, Ontario; University of Waterloo, Toronto
France	University of Strasbourg
Germany	Freie Universität Berlin; Leibniz Universität, Hannover
Italy	International School for Advanced Studies (SISSA)
UK	University of Reading
USA	Auburn University; Colorado School of Mines; Oklahoma State University; Pennsylvania State University; University of Alabama; University of Maryland; University of Memphis; University of Minnesota; University of Missouri; University of Southern California; University of Texas; University of Utah

+ ICTP-IAEA Sandwich Training Educational Programme (STEP)

STEP offers fellowship opportunities to PhD candidates from developing countries in scientific fields covered by both the IAEA Technical Cooperation Programme and falling in the scientific and technical competence of ICTP and its collaborating institutions.

STEP fellowships include a three- to six-month stay each year for three successive years at ICTP or collaborating institutions (ELETTRA, ICTP Laser Laboratory, ICGEB, ICS-UNIDO, Universities of Trieste and Udine, ARPA, IAEA Laboratories in Seibersdorf, Jozef Stefan International Postgraduate School in Ljubljana, Hospitals of Udine and Trieste, and others). Fellows can work on their PhD theses with their supervisors at their home institutes and co-supervisors at the hosting institutes. Their PhD is awarded at their home institutes.

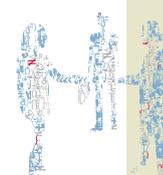
In addition to ICTP and IAEA, the STEP programme receives funding from the Central European Initiative (CEI) and the Japanese government through the UNESCO-ICTP Mori Fellowship scheme (until 2009).

In 2009, 40 fellows (14 women) participated in the programme for a total of 46 visits.



↑
Diploma programme
awards ceremony,
21 August 2009

Abdou Ciss Wade,
STEP student,
in ICTP Laser
Laboratory



+ ICTP-University of Trieste Laurea Magistralis in Fisica, and in Astrofisica e Fisica Spaziale

Both courses are covered in two academic years. The Italian “Laurea Magistralis” degree corresponds to an advanced masters’ degree. The programme is open to anyone having the equivalent of a bachelor degree in physics. A limited number of fellowships are awarded to the best students from developing countries. Upon successful completion of the entire study plan, students are awarded a degree from the University of Trieste.

In 2009, fellowships were awarded to three students. Seven students were enrolled in the programme in 2009.

+ PhD Programme in Environmental Fluid Mechanics

This is a joint programme sponsored by ICTP, the University of Trieste, and three Italian scientific institutions in Trieste: Istituto di Scienze Marine del Consiglio Nazionale delle Ricerche (ISMAR-CNR), Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS), and Osservatorio Meteorologico Regionale - Friuli Venezia Giulia (OSMER-FVG). Now in its fourth year, the programme is patterned after a typical American PhD programme. In 2009, ICTP sponsored one student from Iran.

Training and Education at ICTP: Science Career Support

+ Associateship Scheme

The Associateship Scheme is one of ICTP's oldest programmes, established to provide support for distinguished scientists in developing countries in an effort to lessen the brain drain. The Scheme enables individual scientists to maintain long-term, formal contacts with the stimulating and active scientific environment of ICTP.

In 2009, 622 Associate Members were appointed (19% women). They generated 206 visits by 200 individuals.

+ Federation Arrangements Scheme

Federation Arrangements are contracts of scientific collaboration between ICTP and scientific institutions in developing countries. The arrangement allows the collaborating institutes to send junior representatives to ICTP, on a cost-sharing basis, for an average stay of one month (but up to six months, depending on the location of the country).

In 2009 ICTP had a total of 112 Federation Arrangements. The total number of visits under the programme was 76.

+ Training and Research in Italian Laboratories (TRIL)

The TRIL programme gives scientists from developing countries the opportunity to spend periods ranging from a few months to one year at Italian research laboratories in universities, governmental facilities and private institutions. Activities include academic studies as well as practical applications and industrial projects.

Over the past 25 years, TRIL has awarded 1,836 grants to 1,215 fellows from 82 countries for a total of 17,566 person-months. Some 400 Italian laboratories have participated in the programme. The total number of TRIL fellows present in Italian laboratories in 2009 was 107, while 76 new grants and 33 extensions to existing grants were awarded.

A number of fellowships (17) were awarded under the project "Training and Research in Italian Laboratories (TRIL) for Africa" financed by the Italian funds-in-trust with UNESCO for high-level training and participation in research. The fellows funded by this project were from Côte d'Ivoire, Ethiopia, Ghana, Madagascar, Nigeria, Senegal, South Africa, and Sudan. Training topics included renewable energy, Earth and environmental sciences and medical physics. The same project financed four fellowships to selected students from Ghana, Iran and Senegal for the joint programme with the University of Trieste Laurea Magistralis in physics.

In addition, the Italian funds-in-trust programme is supporting the project "Study of air quality by means of Differential Optical Absorption Spectroscopy (DOAS) in the Accra-Thema industrial area of Ghana", in collaboration with the Institute of Atmospheric Sciences and Climate (ISAC, Bologna) of the Italian National Research Council (CNR), and the Laser and Fibre Optics Centre of the University of Cape Coast, Ghana. It aims to establish the first ground-based station devoted to environmental and climatological observations by means of DOAS in Ghana.

A new announcement of fellowships was published, in the frame of the collaboration agreement with ELETTRA. Altogether, eight TRIL fellows visited ELETTRA in 2009.

A collaboration agreement was signed between ICTP and the Iraqi Ministry of Higher Education and Scientific Research (MOHESR) to support research in lasers, optical communications,



renewable energies, Earth and environmental sciences, medical physics, and technological research, by allowing Iraqi scientists and postgraduate students to visit Italian laboratories. Two fellowships were granted in 2009 under this agreement.

+ ICTP-ELETTRA Users Programme

This programme offers access to the synchrotron radiation facility ELETTRA in Trieste to scientists from developing countries who work in those countries. The programme also offers a limited number of grants to cover travel and living expenses of individuals and small groups who participate in the beamtime at ELETTRA. The number of scientists who can receive support depends on the number of allocated shifts and available funds.

A minimum annual total of 1,500 hours is made available within this programme for short projects such as measurements or other applications at any of the existing ELETTRA beamlines. A total of 2,392 hours of beamtime were allocated in 2009, which indicates the overwhelming success of the programme.

In 2009, ICTP supported 36 visits of participants coming from:

Argentina	1	Pakistan	3
Brazil	5	Singapore	2
China	3	South Africa	1
Cuba	2	Sri Lanka	1
India	13	Thailand	2
Mexico	2	Ukraine	1

+ Synchrotron light for Experimental Science and Applications in the Middle East (SESAME)

SESAME aims to build a synchrotron light source in Jordan, at Al Bal'qa University, and to operate it as an international laboratory for all scientists in the region. ICTP is helping to train Middle Eastern scientists and engineers in the use of the facility by giving young scientists from the region an opportunity to spend six months or more at ELETTRA and other facilities in Europe. The IAEA-STEP programme also offers training opportunities for PhD students from SESAME countries.

There has been excellent progress in the project during 2009: SESAME has moved to its own premises; a microtron is being installed; and the facility has its first generation of beamlines.

+ ICTP Visitors' Programme

Besides high-level training courses, workshops, conferences, topical meetings and regular research activities that take place throughout the year at ICTP, the Centre's scientific sections also offer visitor programmes, providing scientists from developing countries with opportunities to conduct research and to study new developments in physics and mathematics thanks to generous funding received by the Centre.

3.3 Specialized Training



+ Aeronomy and Radiocommunications

ARPL organized two training activities related to aeronomy. A workshop on “Satellite Navigation Science and Technology for Africa”, organized and co-financed by Boston College, USA, aimed to increase global navigation satellite science and applications expertise in Africa and to further develop science collaborations with African universities by promoting the establishment of research groups interested in the field. For this reason, professors or senior lecturers were invited to attend together with junior scientists nominated by them.

A follow-up meeting was held in Nigeria to promote the establishment of a national effort towards the creation of a network of research groups in satellite navigation related activities.

ARPL activities in information technology and radiocommunications covered in-house training and capacity building and in-site activities linked essentially to the use of radio systems in information and communication technologies for developing countries. Research and application activities in the area of wireless sensors are continuing to acquire the capacity to transfer this new technology to developing countries. A joint agreement with ITU on “ICT Technology Observatory and Training Unit for Developing Countries” continued its operation in 2009.

With funds from the UNESCO funds-in-trust programme, ARPL is preparing and planning for wireless network training. It has concentrated its efforts on the development of a wireless training kit that provides all necessary elements needed to conduct a one-week, hands-on training activity in a developing country. The main targets are academic institutions seeking to enrich their scientific and engineering curricula with a short course on wireless networking. After attending such an activity, participants should be able to understand the basics of Wi-Fi networking, including topics such as how to choose the right antenna, how to properly install Wi-Fi equipment, and how all of this fits into their existing network.

+ Biosciences (Biophysics and Neurophysics)

Biophysics is at present the subject of genuine interest for an appreciable number of ICTP scientists who belong to the Associateship Scheme. This wave of interest is partly due to advanced physical techniques that have allowed the systematic study of all the main macromolecules of life.



Satellite Navigation
Science
and Technology
for Africa,
23 March -9 April 2009



Neurophysics has been developed at ICTP through a series of colleges and symposia in collaboration with SISSA (the Antonio Borsellino Colleges), in which many participants from developing countries and industrialized nations have been brought up to date in their areas of expertise.

+ Fluid Mechanics

In addition to basic research activities, ICTP's Fluid Dynamics Laboratory supports advanced courses for PhD students at the University of Trieste (a course in experimental methods in fluid mechanics) and basic skills development for those scientists who want to join international research teams. The laboratory has planned training activities in optofluidics/optical manipulation jointly with the laser centre in Cape Coast, Ghana and with TASC in Trieste.

The laboratory is also made available to students in ICTP's Diploma Programme in condensed matter and Earth system physics who wish to do an experimentally based thesis. The laboratory hosted two STEP students in 2009, and supervised four students from the joint PhD programme in environmental fluid mechanics.

+ Information and Communication Technology

In addition to the computing support services it provides to ICTP's Trieste campus, the Centre's Information and Communication Technology Section (ICTS) participates in training activities that benefit developing countries. The section helps organize training activities, both in Trieste and abroad, in the areas of High Performance Computing (HPC) and Grid computing to help improve research infrastructure in Africa.

During 2009, ICTS coordinated several activities in HPC, including an intensive, three-week workshop on the installation and maintenance of HPC equipment for computational physics. Of the 10 participants, eight were from Africa. Several of these participants applied their skills soon after, installing new HPC equipment for climate modelling donated by ICTP at Addis Ababa University, under the watchful eyes of a team from ICTP. A ceremony to officially commission the equipment was held the same month, and was attended by representatives from the University, ICTP, the UN, and the Italian Embassy in Addis Ababa, as well as the Ethiopian Meteorological Agency and the Meteorological Society of Ethiopia.

In July, ICTP met with representatives from several African countries at Addis Ababa University to discuss the creation of a master's programme in HPC for three African institutions. Meeting participants developed a joint curriculum, discussed the goals, and agreed on a target starting date of September 2010.

+ Optics and Lasers

The ICTP Laser Laboratory is a collaborative experimental facility serving the needs of both ICTP and ELETTRA. It serves as a training facility for ICTP STEP students and TRIL fellows and provides research opportunities for Associates in addition to its function as a support laboratory for the new Free Electron Laser at ELETTRA.

The laboratory is strongly involved in the development of the ultrafast laser systems for the FERMI@Elettra project. FERMI will be a seeded, Free Electron Laser (FEL) facility, including several state-of-the-art laser systems. The development of low-cost ultrafast lasers has applications to fundamental studies of DNA cross-linking, and the Laser Laboratory is collaborating with the International Centre for Genetic Engineering and Biotechnology (ICGEB) of Trieste in this area.

The lab is also involved in the study of laser "tweezers" for the manipulation of microscopic biological objects. This work is done in collaboration with the TASC laboratory.

Training and Education in Developing Countries

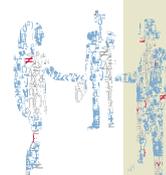
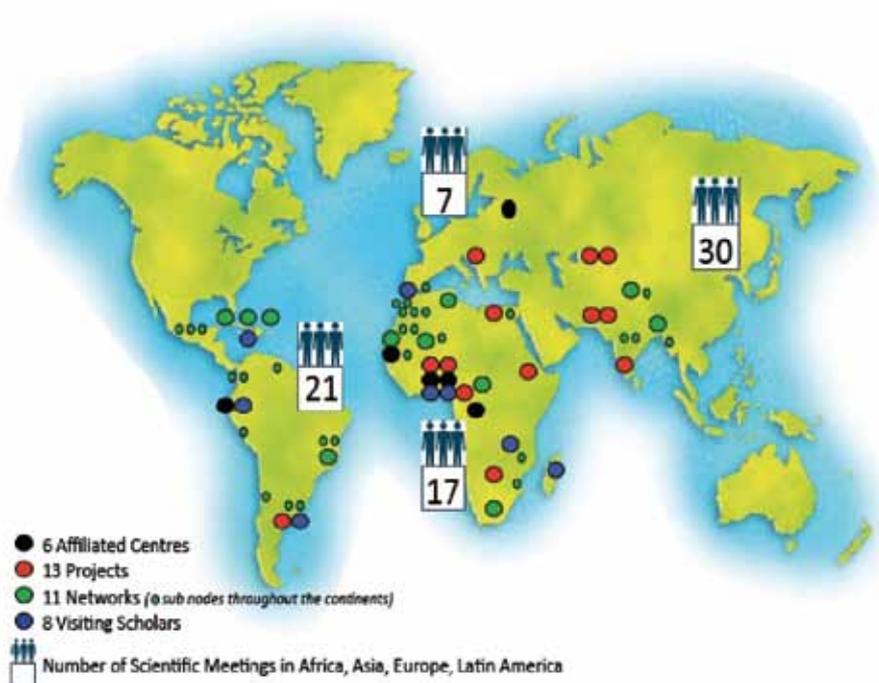
ICTP's Office of External Activities (OEA) coordinates physics and mathematics research and training activities in developing countries. Such support complements the training and research provided through the Centre's Trieste-based programmes. OEA provides funds for student grants, fellowships for young researchers, visits of research collaborators, equipment, and printed materials.

This support is meant to help developing countries accelerate their promotion to an international level (South-North collaboration) and to stimulate networking of scientists in the developing regions to reach a critical mass of researchers (South-South collaboration). For a detailed listing of OEA activities in 2009, please see the accompanying CD.

Assistance is carried out within the following schemes:

- **Affiliated Centres:** these are institutes or university departments of physics or mathematics that carry out a specific, long-term research project on a definite subject with well-defined purposes. Affiliated Centres have a regional character and are strongly supported by the local authorities and the hosting institute. In 2009, OEA supported six Affiliated Centres: four in Africa, one in Latin America, and one in Eastern Europe.

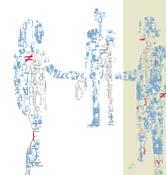
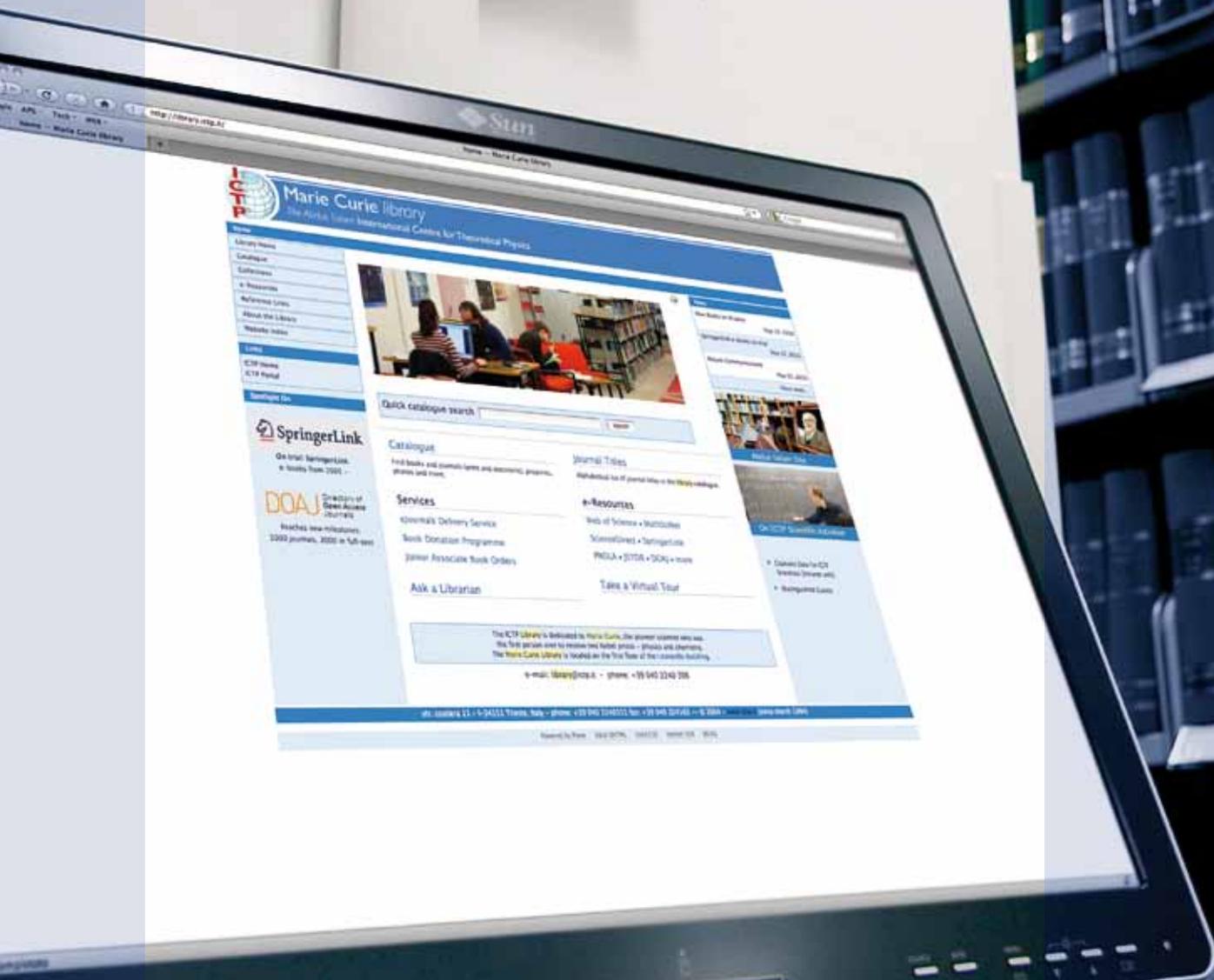
OEA Activities 2009



- **Projects:** OEA Projects encourage students from developing countries who pursue their graduate studies in industrialized nations to return to their countries of origin. OEA Projects also support specific PhD courses (primarily in Africa). In 2009, there were 13 active projects, of which six were in Africa, five in Asia, one in Eastern Europe, and one in Latin America.
- **Network Programme:** An ICTP Network is a system of research groups in an entire region, or among different regions, that pursue a common scientific project over an extended period. In 2009, OEA supported 11 networks in various fields of physics and mathematics. There are five networks in Africa including North Africa; two in Asia and four in Latin America and the Caribbean.
- **Scientific Meetings:** OEA encourages the organization of international and regional scientific meetings in developing countries by offering financial assistance to the organizers of conferences, workshops, and schools. In 2009, 75 scientific meetings received support.
- **Visiting Scholars/Consultants:** This programme promotes collaboration between scientists in developing countries and leading scientists throughout the world. The Visiting Scholar/Consultant is required to make at least two research visits over three years, each lasting at least a month, during which they are expected to carry out joint research with their counterparts and deliver lectures in their fields of expertise. During 2009 there were eight new Visiting Scholars.
- **Collaborations:** OEA collaborates with other institutions in promoting research and training in physics and mathematics in developing countries. In particular there are collaborations with the Centro Latino-Americano de Física (CLAF) that include research exchange visits and sandwich PhD programmes. This collaboration has been very fruitful.

4.0 Scientific Support Services

Online Catalogue



ICTP places fundamental support services at the disposal of its scientists. The Centre's **Marie Curie Library**—containing 67,000 volumes, 341 print subscriptions to print journals, and electronic access to nearly 4,000 journals—offers visitors one of the largest collections of literature in physical and mathematical sciences in Europe. In 2009, the Library launched its redesigned website. The online catalogue integrated several digital archives, which made its traffic volume grow from 1.1 GB to 11.5 GB in one year. Usage of the Library's e-Journals Delivery Service (eJDS), a cost-free service for the distribution of scientific articles via e-mail to individual scientists in least developed or low-income countries, has almost doubled in the last year.

Workshop on Scientific
Information in the
Digital Age: Access
and Dissemination,
12-16 October 2009
(Courtesy: SDU)



The award-winning **Science Dissemination Unit (SDU)** researches and develops innovative, low-cost information and communication technology (ICT) solutions for developing countries, and disseminates science texts via electronic media. Ongoing SDU activities include the development and maintenance of the award-winning “Enhance your Audience” or EyA system, which webcasts all physics and mathematics lectures given through ICTP's Diploma Programme, as well as selected ICTP conferences and workshops. SDU also remotely monitors end-to-end performance of internet connectivity in Africa via its PingER (Ping End-to-end Reporting) project.



The ICTP **Information and Communication Technology Section** provides informatic services for the ICTP community (scientific and administrative) and for the scientific activities of ICTP.

ICTP's **Publications and Printing Unit** disseminates the knowledge created or updated by ICTP scientists through preprints, and the *ICTP Lecture Notes Series*. Some 10,000 articles in various fields have been published since 1964. All of ICTP's preprints are now online.

A computer lab
in the Leonardo Building



The African Physical Review (APR) is a free, on-line, peer reviewed, international journal founded by ICTP that publishes reviews, research articles, and brief communications in all branches of experimental and theoretical physics. One goal of the journal is to assist competent African scientists to become more proficient in writing scientific papers. In 2009, a special issue on electronics and materials was published. In October 2009, the newly formed African Physical Society named *The African Physical Review* as its official journal.



ICTP is funded largely through generous contributions made by the Italian government, which has served as ICTP's chief benefactor since the Centre's inception. ICTP operates under a joint administrative framework established by the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the International Atomic Energy Agency (IAEA). UNESCO also serves as the Centre's leading administrative agency.

INCOME FOR 2009 (IN €):

Italian Government:	17,995,290.00
IAEA:	2,384,014.00
UNESCO:	441,017.00
Total of mandatory contributions:	20,820,321.00
Plus voluntary contributions:	2,363,786.43
Total Income 2009:	23,184,107.43

In 2009, ICTP received voluntary contributions from a number of organizations, including:

EUROPEAN COMMISSION through:

- Central European Initiative, Italy
- Danish Meteorological Institute, Denmark
- Ecole Polytechnique, Palaiseau, France
- Fraunhofer-Gesellschaft, Munich, Germany
- Met Office, Exeter, UK
- Natural Environmental Research Council, Swindon, UK
- Pildo Laboratories, Barcelona, SP
- Swedish Institute of Computer Science, Kista, Sweden
- University of Geneva, Switzerland
- University of Warwick, Coventry, UK

EUROPEAN SCIENCE FOUNDATION (ESF)

FRANCE:

- Commissariat à l'Énergie Atomique (CEA)
- IEEA Courbevoie

GALILEO JOINT UNDERTAKING (through the France Developpement Conseil, Vincennes, France)

GERMANY - Physikalisch-Technische Werkstätten, Freiburg

INTERNATIONAL ASSOCIATION OF SEISMOLOGY AND PHYSICS OF THE EARTH INTERIOR

(IASPEI), c/o Dipartimento di Scienze della Terra, Università di Trieste

INTERNATIONAL ASSOCIATION OF VOLCANOLOGY AND CHEMISTRY OF THE EARTH

INTERIOR (IAVCEI), c/o Institute of Earth Sciences "Jaume Almera", Barcelona, Spain

INTERNATIONAL ATOMIC ENERGY AGENCY (IAEA)

INTERNATIONAL CENTRE FOR GENETIC ENGINEERING AND BIOTECHNOLOGY (ICGEB)

INTERNATIONAL GEOTHERMAL ASSOCIATION

INTERNATIONAL MATHEMATICAL UNION (IMU)

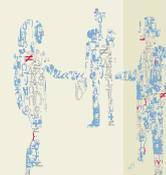
INTERNATIONAL TELECOMMUNICATION UNION (ITU)

INTERNATIONAL UNION OF PURE AND APPLIED PHYSICS (IUPAP)

IRAN - Ministry of Science, Research and Technology

ITALY:

- Central European Initiative (CEI)
- Centro di Ecologia Teorica ed Applicata (CETA)
- Centro Europeo Mediterraneo per i Cambiamenti Climatici (CMCC)
- CNR/Istituto Nazionale per la Fisica della Materia (INFN)
- CNR/Istituto di Scienza dell'Atmosfera e del Clima (ISAC)
- CNR/Istituto per lo Studio dei Materiali Nanostrutturati (ISMN)



CNR/Istituto di Scienze e Tecnologie dell' Informazione (ISTI)
 Consorzio Venezia Nuova
 Emerging Nations Science Foundation, c/o ICTP
 Ente Nazionale per le Nuove Tecnologie, l'Energia e l'Ambiente (ENEA)
 Eurotech S.p.A.
 E4 Computer Engineering S.p.A.
 Gruppo Illiria S.p.A.
 IBM Italia S.p.A.
 Istituto Nazionale di Astrofisica, Osservatorio Astronomico di Trieste (INAF/OAT)
 Istituto Nazionale di Fisica Nucleare (INFN)
 Istituto Nazionale di Geofisica e Vulcanologia (INGV)
 Istituto Nazionale di Oceanografia e Geofisica Applicata (OGS)
 Istituto Nazionale di Ricerca Metrologica (INRIM)
 Regione Autonoma Friuli Venezia Giulia
 Scuola Internazionale Superiore di Studi Avanzati (SISSA)
 Sincrotrone Trieste ScpA
 Spring Firm S.r.l.
 Stazione Zoologica Anton Dohrn
 SWG S.r.l.
 Università degli Studi di Bologna
 Università degli Studi di Firenze
 Università degli Studi di Milano
 Università degli Studi di Trieste

KOREA - Asian Pacific Centre for Theoretical Physics (APCTP)

NORWAY - Research Council of Norway, through the University of Oslo

SWEDEN:

RTI Electronics AB, Mölndal
 Unfors Instruments AB, Billdal

SWITZERLAND:

Centre Européen de Calcul Atomique et Moléculaire (CECAM)
 ICTP Swiss Friends
 Specs-Zurich GmbH

THE ACADEMY OF SCIENCES FOR THE DEVELOPING WORLD (TWAS)

UK:

Photron Ltd.
 Psi-k, Daresbury Laboratory
 Science & Technology Facilities Council, Rutherford Appleton Laboratory
 The Wellcome Trust Limited, c/o Imperial College, London

UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION (UNESCO)

USA:

American Agencies and Institutions (through Dr. S. Abarzhi)
 Banco Interamericano de Desarrollo (through ENEA, Italy)
 Boston College Trustee
 Center for Ocean-Land-Atmosphere Studies (COLA)
 European Office of Aerospace Research and Development
 International Centre for Materials Research (ICMR)
 International Institute for Complex Adaptive Matter (I2CAM)
 Massachusetts Institute of Technology (MIT)
 Optical Society of America (OSA)
 Radcal Corporation

UNAVCO Inc.

WORLD METEOROLOGICAL ORGANIZATION (WMO)

DONATION:

Professor C. Vafa (2008 Dirac Prize)

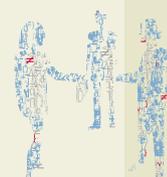
Scientific Staff

Acharya, Bobby	Researcher	HECAP
Aoudia, Abdelkrim	Research Scientist	ESP
Bi, Xunqiang	Assistant Research Scientist	ESP
Binggeli, Nadia	Research Scientist	CMSP
Chidume, Charles	Research Scientist (until 31/8/2009)	Math
Creminelli, Paolo	Research Scientist	HECAP
Gebauer, Ralph	Researcher	CMSP
Giorgi, Filippo	Head, Earth System Physics Section	ESP
Göttsche, Lothar	Research Scientist	Math
Kiselev, Mikhail	Research Scientist	CMSP
Kravtsov, Vladimir	Head, CMSP	CMSP
Kucharski, Fred	Research Scientist	ESP
Lê, Dung Tráng	Head, Mathematics (until 31/12/2009)	Math
Li, Jiayu	Research Scientist (until 31/12/2009)	Math
Luzzatto, Stefano	Mathematician (from 1/4/2009)	Math
Marsili, Matteo	Researcher	CMSP
Müller, Markus	Research Scientist (from 27/2/2009)	CMSP
Narain, Kumar	Research Scientist	HECAP
Niemela, Joseph	Research Scientist	AP
Quevedo, Fernando	Director (from 5/11/2009)	
Ramakrishnan, Ramadas	Co-Head, Associateship and Federation Schemes	Math
Randjbar-Daemi, Seifallah	Assistant Director; Head, HECAP	HECAP
Scandolo, Sandro	Senior Researcher	CMSP
Scardicchio, Antonello	Research Scientist (from 19/1/2009)	CMSP
Senjanovic, Goran	Research Scientist	HECAP
Smirnov, Alexei	Principal Research Scientist	HECAP
Sreenivasan, Katepalli R.	Director (until 4/11/2009)	
Thompson, George	Head, Office of External Activities	HECAP
Tompkins, Adrian	Research Scientist	ESP
Tuniz, Claudio	Assistant Director; Head, MLab	AP

Administrative Staff

Gatti, Anne	Programme Support Officer
Johannessen, Dag	Assistant Director (Administration)
Jost, Erich	Administrative Services Officer
Michelcich, Andrej	Senior Budget and Finance Officer
Nobile, Alvise	Head, Information and Communication Technology Section (until 31/12/2009)
Onime, Clement	System and Network Analyst
Terdina, Giorgio	Supervisor, Administrative Computer Services
Williams, Mary Ann	Public Information Officer (from 7/1/2009)

In addition, ICTP employed 109 General Service staff in 2009.



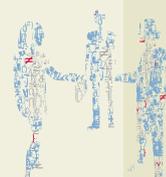
Research Staff Associates

Brankovic, C.	Staff Associate	ESP
Chela-Flores, J.	Staff Associate	AP
Gribkov, V.	Staff Associate	MLab
Kang, I.-S.	Staff Associate	ESP
Kumar, N.	Staff Associate	CMSP
Laudal, O.A.	Staff Associate	Math
Nersesyan, A.A.	Staff Associate	CMSP
Radicella, S.M.	Staff Associate	ARPL
Seade Kuri, J.	Staff Associate	Math
Yudson, V.I.	Staff Associate	CMSP

Long-term Visiting Researchers

Abdussalam, S.	Post-doctoral Fellow	HECAP
Adeluyi, O.O.	Long-term Scientist	MLab
Akin-Ojo, O.	Post-doctoral Fellow	CMSP
Al Yasry, A.Z.	Post-doctoral Fellow	Math
Anand, K.	Post-doctoral Fellow	CMSP
Andreanov, A.	Post-doctoral Fellow	CMSP
Bernardini, F.	Long-term Scientist	MLab
Bhattacharya, S.	Post-doctoral Fellow	CMSP
Bianconi, G.	Post-doctoral Fellow	CMSP
Bisignano, D.	Long-term Scientist	SAND
Borghini, M.	Long-term Scientist	ESP
Boumazgour, M.	Post-doctoral Fellow	Math
Bremang Tandoh, J.	Long-term Scientist	MLab
Castaño-Bernard, C.	Post-doctoral Fellow	Math
Chatterjee, A.	Post-doctoral Fellow	CMSP
Christie, J.K.	Post-doctoral Fellow	CMSP
Coppola, E.	Post-doctoral Fellow	ESP
Dabashis, B.	Long-term Scientist	MLab
Dall'Asta, L.	Post-doctoral Fellow	CMSP
Darwish, M.A.	Post-doctoral Fellow	Math
Das, A.	Post-doctoral Fellow	CMSP
Detalla, A.L.	Post-doctoral Fellow	Math
Dimitrova, O.V.	Post-doctoral Fellow	CMSP
Dimitrova, S.	Long-term Scientist	SAND
Dinar, Y.	Post-doctoral Fellow	Math
Diro, G.T.	Post-doctoral Fellow	ESP
Enkhbat, T.	Post-doctoral Fellow	HECAP
Fang, L.	Long-term Scientist	SAND
Feudale, L.	Post-doctoral Fellow	ESP
Franchini, F.	Post-doctoral Fellow	CMSP

Garcia Garcia, A.M.	Long-term Scientist	CMSP
Ghosh, P.	Post-doctoral Fellow	CMSP
Giacomazzi, L.	Post-doctoral Fellow	CMSP
Greco, B.	Long-term Scientist	SAND
Gu, P.-H.	Post-doctoral Fellow	HECAP
Guidarelli, M.	Post-doctoral Fellow	ESP
Habib, R.	Long-term Scientist	SAND
Huang, H.-L.	Post-doctoral Fellow	Math
Im, E.-S.	Post-doctoral Fellow	ESP
Inam, F.	Post-doctoral Fellow	CMSP
Joo, J.-H.	Post-doctoral Fellow	ESP
Lee, M.-S.	Post-doctoral Fellow	CMSP
Longo, G.S.	Post-doctoral Fellow	CMSP
Lukose, V.	Post-doctoral Fellow	CMSP
Musso, M.	Post-doctoral Fellow	HECAP
Nalleparambil J.S.	Post-doctoral Fellow	Math
Nazir, S.	Post-doctoral Fellow	Math
Ngueyn, T.K.T.	Post-doctoral Fellow	CMSP
Pancholi, D.	Post-doctoral Fellow	Math
Paranjape, A.	Post-doctoral Fellow	HECAP
Parthasarathi, R.	Post-doctoral Fellow	Math
Piani, C.	Long-term Scientist	ESP
Pinilla, C.	Post-doctoral Fellow	CMSP
Rabanal, R.	Post-doctoral Fellow	Math
Rasulov, T.H.	Post-doctoral Fellow	Math
Rauscher, S.	Post-doctoral Fellow	ESP
Seriani, N.	Post-doctoral Fellow	CMSP
Shahoo, B.	Post-doctoral Fellow	HECAP
Silva, A.	Long-term Scientist	CMSP
Smogunov, A.	Post-doctoral Fellow	CMSP
Soyler, S.N.	Post-doctoral Fellow	CMSP
Stojic, N.	Long-term Scientist	CMSP
Surendran, N.	Post-doctoral Fellow	CMSP
Suruliz, K.	Post-doctoral Fellow	HECAP
Sylla, B.	Long-term Scientist	ESP
Torabian, M.	Post-doctoral Fellow	HECAP
Tran, V.T.	Post-doctoral Fellow	Math
Tsumura, K.	Post-doctoral Fellow	HECAP
Velasco-Sevilla, L.	Post-doctoral Fellow	HECAP
Vivo, P.	Post-doctoral Fellow	CMSP
Wang, C.	Post-doctoral Fellow	CMSP
Wang, M.	Post-doctoral Fellow	Math
Yadav, R.K.	Post-doctoral Fellow	ESP



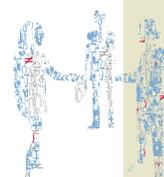
Yechoui, A.	Post-doctoral Fellow	Math
Yee, H.-U.	Post-doctoral Fellow	HECAP
Zakey, A.	Post-doctoral Fellow	ESP
Zandomeneghi, D.	Long-term Scientist	MLab
Zhang, S.	Long-term Scientist	SAND
Zhang, X.	Long-term Scientist	SAND
Zhang, Y.	Post-doctoral Fellow	HECAP
Zheng, B.	Post-doctoral Fellow	CMSP
Zu, X.	Post-doctoral Fellow	Math

Scientific Consultants

Altshuler, B.	CMSP
Bertocchi, L.	Director's Office/Medical Physics
Canessa, E.	SDU
Cozzini, S.	ICTS
Crespo, M.L.	MLab
Fabrizio, M.	CMSP
Flickenger, R.	ARPL
Fonda, C.	ARPL
Furlan, G.	TRIL Programme
Gava, E.	HECAP
Ghirardi, G.C.	Associateship Programme
Giovanelli, G.	TRIL Programme
Kostadinov, I.	TRIL Programme
Malabotta, M.	ICTS
Migoya Orué, Y.O.	ARPL
Nava, B.	ARPL
Panza, G.	ESP
Santoro, G.	CMSP
Tosatti, E.	CMSP
Treleani, D.	TRIL Programme
Zennaro, M.	ARPL



ICTP's Scientific Council is composed of distinguished specialists in disciplines relevant to the Centre's activities and representing a broad geographical range. The Council advises ICTP on its programmes of activities, taking into consideration major academic, scientific, educational and cultural trends relevant to the Centre's objectives.



+ ICTP Scientific Council

F.K.A. Allotey

Director
Institute of Mathematical Sciences (IMS)
Legon-Accra, Ghana

Akito Arima

Chairman
Japan Science Foundation
Tokyo, Japan

Riccardo Barbieri

Scuola Normale Superiore
Pisa, Italy

Nicola Cabibbo, Chairperson

Università degli Studi di Roma "La Sapienza"
Rome, Italy

Jia'er Chen

Peking University
Beijing, China

Claude Cohen-Tannoudji

Ecole Normale Supérieure
Paris, France

Paul J. Crutzen

Max-Planck-Institute for Chemistry
Mainz, Germany
and
Scripps Institution of Oceanography, UCSD
La Jolla, CA, USA

James Langer

University of California at Santa Barbara
Santa Barbara, CA, USA

Vladimir Lebedev

L.D. Landau Institute of Theoretical Physics
Moscow, Russian Federation

José Antonio de la Peña

Universidad Nacional Autónoma de México
México City D.F., Mexico

S. George H. Philander

Department of Geosciences
Princeton University
Princeton, NJ, USA

Ashoke Sen

Harish-Chandra Research Institute
Allahabad, India

Jean-Christophe Yoccoz

Collège de France
Paris, France

+ ICTP Steering Committee

The ICTP Steering Committee, comprising representatives from UNESCO, IAEA and the Italian government, sets general guidelines for the Centre's activities, determines budgeting levels, and considers proposals from the Director for the programme, work plans, financial plans, and budget. The ICTP Director is the ex-officio chairperson of the Steering Committee. The chairperson of the Scientific Council attends the Steering Committee meeting in an advisory capacity. Members of the Steering Committee may be accompanied by experts.

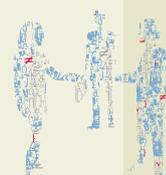


UNESCO:
Walter Erdelen
Assistant Director General for Natural Sciences

IAEA:
Werner Burkart
Deputy Director General
Head of the Department of Nuclear Sciences and Applications

Italian Government:
Roberto Petronzio
President
Istituto Nazionale di Fisica Nucleare (INFN)

↑
Walter Erdelen,
Werner Burkart,
Roberto Petronzio,
Nicola Cabibbo,
and **Katepalli R. Sreenivasan**



Regular scientific activities at ICTP

Number of conferences/workshops: 58

Number of visitors: 5050

Female: 1075 (21%)

Male: 3975

Number of person-months: 4309 (131,074 days)

Nations represented: 137

Hosted activities (held at ICTP but organized by external groups)

Number of conferences: 34

Participants: 1922

Total number of scientific visitors: 6972**ICTP regional training activities**

Region	Number of Activities	Country
Africa	1	South Africa
Asia	2	Uzbekistan, Viet Nam
Latin America	3	Brazil, Chile, Colombia.
Europe	4	Greece, Netherlands, Romania [2]

Region of origin, ICTP visitors

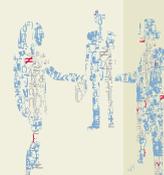
Regions	Visitors from...					Person-months					Total	
	LDCs*	Developing Regions	Transition Countries	CIS**	Developed Regions	LDCs*	Developing Regions	Transition Countries	CIS**	Developed Regions	Visitors	Person-months
Africa	196	477	—	—	—	373.48	654.80	—	—	—	673	1028.28
Asia	50	1029	—	90	58	83.08	1152.75	—	91.33	16.70	1227	1343.86
Europe	—	—	130	193	1773	—	—	101.65	137.92	1051.62	2096	1291.19
Latin America and the Caribbean	—	503	—	—	—	—	430.55	—	—	—	503	430.55
North America	—	—	—	—	535	—	—	—	—	210.77	535	210.77
Oceania	—	—	—	—	16	—	—	—	—	4.60	16	4.60
GRAND TOTAL	246	2009	130	283	2382	456.56	2238.10	101.65	229.25	1283.69	5050	4309.25
% vs. Total Visitors	5%	40%	3%	6%	47%	11%	52%	2%	5%	30%		

* Least Developed Countries

** Commonwealth of Independent States

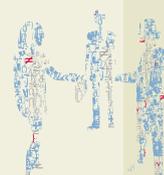
Top 10 ICTP activities (by attendance)

Title	Date	Number of Participants
Fourteenth International Workshop on Computational Physics and Materials Science: Total Energy and Force Methods	08-10/01/2009	230
Summer College on Nonequilibrium Physics from Classical to Quantum Low Dimensional Systems	06-24/07/2009	180
Summer College on Plasma Physics	10-28/08/2009	176
Spring School on Superstring Theory and Related Topics	23-31/03/2009	173
Conference on Research Frontiers in Ultra-Cold Atoms	04-08/05/2009	164
Second International Conference and Advanced School on Turbulent Mixing and Beyond	27/07-07/08/2009	160
Summer School on Particle Physics in the LHC ERA	15-26/06/2009	139
Advanced School and Conference on Knot Theory and its Applications to Physics and Biology	11-29/05/2009	138
Joint ICTP/FANAS Conference on Trends in Nanotribology	19-24/10/2009	118
From DNA-Inspired Physics to Physics-Inspired Biology	01-05/06/2009	115



APCTP	Asia Pacific Center for Theoretical Physics
ARPA	Agenzia Regionale per la Protezione dell'Ambiente nella Regione Friuli Venezia Giulia
AUST	African University of Science and Technology
CEA	Commissariat à l'Énergie Atomique (Atomic Energy Commission)
CECAM	Centre Européen de Calcul Atomique et Moléculaire (European Centre for Atomic and Molecular Calculus)
CEI	Central European Initiative
CERN	European Laboratory for Particle Physics
CETA	Centro di Ecologia Teorica ed Applicata (Centre for Theoretical and Applied Ecology)
CLAF	Centro Latino Americano de Física (Latin-American Centre for Physics)
CMCC	Centro Euro-Mediterraneo per i Cambiamenti Climatici (Euro-Mediterranean Centre for Climatic Change)
CNR	Consiglio Nazionale delle Ricerche (Italian National Research Council)
COLA	Center for Ocean, Land and Atmosphere
ELETTRA	ELETTRA Synchrotron Light Laboratory
ESF	European Science Foundation
ENEA	Italian National Agency for New Technologies, Energy and the Environment
I₂CAM	International Institute for Complex Adaptive Matter
IAEA	International Atomic Energy Agency
IASPEI	International Association of Seismology and Physics of the Earth's Interior
IAVCEI	International Association of Volcanology and Chemistry of the Earth's Interior
ICGEB	International Centre for Genetic Engineering and Biotechnology
ICMR	International Center for Materials Research
ICO	International Commission for Optics
ICS-UNIDO	International Centre for Science and High Technology of UNIDO
ICTP	The Abdus Salam International Centre for Theoretical Physics
IMU	International Mathematical Union
INAF	Istituto Nazionale di Astrofisica (National Institute of Astrophysics)
INFN	Istituto Nazionale di Fisica della Materia (Italian National Institute for the Physics of Matter)
INFN	Istituto Nazionale di Fisica Nucleare (Italian National Institute for Nuclear Physics)
INGV	Istituto Nazionale di Geofisica e Vulcanologia (Italian National Institute of Geophysics and Vulcanology)
INRIM	Istituto Nazionale di Ricerca Metrologica (Italian National Institute of Metrological Research)
IPPLM	Institute of Plasma Physics and Laser Microfusion
ISAC	Institute of Atmospheric Sciences and Climate
ISMAR-CNR	Istituto di Scienze Marine del Consiglio Nazionale delle Ricerche (Institute of Marine Sciences of the Italian National Research Council)

ISMN	Istituto per lo Studio dei Materiali Nanostrutturati (Institute for the Study of Nanostructured Materials)
ISTI	Istituto di Scienze e Tecnologie dell' Informazione (Institute of Information Science and Technology)
ITU/BDT	Telecommunication Development Bureau of the International Telecommunication Union
IUPAP	International Union of Pure and Applied Physics
MIT	Massachusetts Institute of Technology
MOHESR	Iraqi Ministry of Higher Education and Scientific Research
MPS	Moscow Physical Society
OGS	Istituto Nazionale di Oceanografia e Geofisica Sperimentale (National Institute of Oceanography and Experimental Geophysics)
OSA	Optical Society of America
OSMER-FVG	OSservatorio MEteorologico Regionale – Friuli Venezia Giulia (Friuli Venezia Giulia Regional Meteorological Observatory)
SESAME	Synchrotron light for Experimental Science and Applications in the Middle East
SISSA	Scuola Internazionale Superiore di Studi Avanzati (International School for Advanced Studies)
SPIE	The International Society for Optical Engineering
TASC	TASC National Laboratory: Tecnologie Avanzate e nanoSCienza (Advanced Technology and nanoSCience)
TWAS	The Academy of Sciences for the Developing World
UNESCO	United Nations Educational, Scientific and Cultural Organization
WCRP	World Climate Research Programme
WMO	World Meteorological Organization



ICTP Full Technical Report 2009 on CD

The enclosed CD Rom contains the full technical report of ICTP for 2009.
It is in pdf format, on Adobe Reader 9, Version 9.2.0.

The pdf file is searchable.

For easy reference, this pdf file contains bookmarks of sections and chapters.
To go directly the topics of your interest, scroll the bookmarks navigation bar and click on the page or its link.

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Awards and Prizes

Scientific Support Services

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Preprints

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List of Financial Contributors

Participations in Research and Training for Research

Summary of Participations by Scientific Field and Region

Visitors and Person-Months by Country

Acronyms



ICTP
The Abdus Salam
International Centre
for Theoretical Physics

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