



# «ETTORE MAJORANA» FOUNDATION AND CENTRE FOR SCIENTIFIC CULTURE

TO PAY A PERMANENT TRIBUTE TO GALILEO GALILEI, FOUNDER OF MODERN SCIENCE  
AND TO ENRICO FERMI, THE "ITALIAN NAVIGATOR", FATHER OF THE WEAK FORCES

## ETTORE MAJORANA CENTENARY



# INTERNATIONAL SCHOOL OF SUBNUCLEAR PHYSICS

## THE LOGIC OF NATURE, COMPLEXITY AND NEW PHYSICS:

*From Quark-Gluon Plasma to Superstrings, Quantum Gravity and Beyond*

**44th Course – ERICE-SICILY: 29 AUGUST - 7 SEPTEMBER 2006**

Sponsored by the:

- Italian Ministry of Education, University and Scientific Research • Sicilian Regional Government •
- Academies of Sciences of Estonia, Georgia, Lithuania, Russia and Ukraine • Chinese Academy of Sciences •
- Commission of the European Communities • European Physical Society • Weizmann Institute of Science •
- World Federation of Scientists • World Laboratory

### PROGRAMME AND LECTURERS

#### HOMAGE TO RICHARD H. DALITZ

#### THE FIRST BEST STUDENT CELEBRATING THE FIRST MAJORANA CENTENARY

*Neutrino Masses, Leptogenesis and Beyond:  
The Incredible Foresight of Ettore Majorana*  
• H. HARARI, Weizmann Institute of Science, Rehovot, IL

#### OPENING LECTURE

*The Landscape and its Physics Foundations*  
• L. SUSSKIND, Stanford University, CA, USA

#### MINI COURSES

*Complexity and Nonextensive Statistical Mechanics - Theory, Experiments, Observations, and Computer Simulations*  
• M. GELL-MANN, Institute for Complexity, Santa Fe Institute, NM, USA  
• C. TSALLIS, Institute for Complexity, Santa Fe Institute, NM, USA

*QCD at Low Energy: The Simplicity of Complex non-Perturbative Phenomena*  
• G. COLANGELO, University of Bern, CH

#### *The Status of Lattice QCD*

• R.D. KENWAY, University of Edinburgh, Scotland, UK

#### *Complexity in String Theory and Standard Model Parameters*

• C. BECK, University of London, UK

#### *Complexity and Landscape in String Theory*

• F. DENEFF, Katholieke Universiteit Leuven, B & Rutgers University, NJ, USA  
• M.R. DOUGLAS, IHES, Bures-sur-Yvette, F & Rutgers University, NJ, USA

#### *How String Theory Generates the Landscape*

• L. SUSSKIND, Stanford University, CA, USA

#### *Black Holes, Attractors and Quantum Information*

• M.J. DUFF, Blackett Laboratory, Imperial College London, UK

#### *Complexity at the Fundamental Level*

• A. ZICHICHI, CERN, Geneva, CH; INFN & University of Bologna, I

#### HIGHLIGHTS FROM LABORATORIES

##### BNL: Evidence for a Quark-Gluon Plasma at RHIC

• J.W. HARRIS, Yale University, New Haven, CT, USA

##### CERN: LHC upgrade

• H. WENNINGER, CERN, Geneva, CH

##### DESY: Diffraction at the Scale of Quarks and Gluons

• B. LOEHR, DESY, Hamburg, D

##### FERMILAB: Tevatron Physics

• N. LOCKYER, University of Pennsylvania, Philadelphia, PA, USA

##### GRAN SASSO: Neutrino Beams from CERN

• E. COCCIA, LNGS, L'Aquila, I

##### SLAC: Towards New Physics with Rare Processes in CP Violation

• M. GIORGI, University of Pisa, I

##### SUPERKAMIOKANDE: Neutrino Physics

• M. KOSHIBA, University of Tokyo, Kamioka, Gifu, J

#### SEMINARS ON SPECIALISTIC TOPICS

##### *How to Detect Extradimensions*

• I. ANTONIADIS, CERN, Geneva, CH

##### *The Future of Supercomputers*

• R. PETRONZIO, University of Rome II & INFN, Rome, I

#### PROBLEMS OPEN FOR COMPETITION

##### THE FIRST GROUP: MIXINGS

- Why Nature needs the flavour mixings mechanism?
- Why this mechanism produces different results in the Quark and in the Lepton sectors?
- What is the origin of this mechanism which does not exist in any other fundamental interaction?

##### THE SECOND GROUP: ELEMENTARY AND COMPOSITE STATES

- Is there any reason why composite ( $q\bar{q}$ ) or ( $\bar{l}l$ ) scalar particles have never been clearly established?
- Is there a fundamental reason why elementary fermions exist (Quarks and Leptons) but not elementary scalars in the same mass range?
- Do we really need sterile neutrinos? If yes, why? If not, why?

##### THE THIRD GROUP: SYMMETRY BREAKINGS

- Why the various global Symmetry breakings ( $C$ ,  $P$ ,  $CP$ ,  $T$ ) are not via the SSB mechanism?
- To what extent can we be confident that the Supersymmetry breaking threshold is not at the Planck Scale? (If this were the case it would be impossible at LHC to find any evidence for Supersymmetry).
- Are we really sure that the  $E$ - $W$  Symmetry breaking which occurs at the Fermi Scale is due to the existence of an imaginary mass in the Lagrangian? (If this were not the case, it would not be possible at LHC to find any evidence for Higgs particles).

**Board of Lecturers and Invited Scientists:** In addition to the Lecturers of the School, a group of distinguished physicists is invited to contribute to the lively intellectual atmosphere of the School by participating in the discussions following the Lectures. Lecturers and Invited Scientists moreover will take part in the selection of the **New Talents**, to be admitted at the School and in the award of the various scholarships and grants open for competition.

**Competitions to celebrate the Ettore Majorana Centenary:** Celebrations of the **Ettore Majorana Centenary** include a worldwide competition to select **New Talents**. The competition starts with the participation to this year School. Young fellows who think they have the ability to compete for the **New Talents** are invited to apply at this year School. There are **fifty places available** and those selected will have the fees of the School payed plus full board and lodging in Erice for the period of the School and a contribution for travelling expenses. Applications for the **fifty places available** should be sent as soon as possible to the Director of the School. A Permanent Committee (**PC**) composed by the Lecturers and the Invited Scientists will take decisions on real time, i.e. not later than two weeks after the arrival of the letter of application. At the end of the School the **Best Student** will be selected and nine **Best New Talents** from the fifty admitted. The same **PC** will decide on the winners of the competition open for the nine problems and on the special Prizes to be awarded for each solution. The solutions must be presented at the Special Sessions of the School.

**Special Sessions for New Talents:** One of the aims of the School is to encourage and promote young physicists to achieve recognition at an international level. There will be poster sessions whereby each student will have the privilege of presenting the results of current studies and interacting with other participants to their mutual benefit. Each student may also propose a contribution for open presentation. The Board of Lecturers and Invited Scientists will select the best proposals. Priority will be given to the new material of either an experimental or theoretical nature, especially if the candidate has made an important contribution to the results to be presented. A review paper has lower priority and, as before, will only be selected if the candidate can point out some new features in the field reviewed. Due to the large number of students and the limited time available, it is obvious that only selected "New Talents" can be given the possibility of making themselves known. The selection will be based solely on "scientific excellence", without favour to geographical distribution, the Laboratory or the University of origin.

### PURPOSE OF THE SCHOOL

The Logic of Nature allows the existence of Science (the asymptotic limit of Simplicity) and of History (the asymptotic limit of Complexity). Following the Majorana approach to understand the Laws of Nature, this year School will review the present status of all we know in the Reductionistic achievements together with our present understanding of the rigorous attempts towards the basic features which allow Complexity to exist. In fact Nature shows structures which are considered as being complex and the general trend is that, in order to understand their roots, we must go from Reductionism to Holism whose frontier is Complexity. But "**Complexity**" is ill-defined: nevertheless people speak of "Complexity" as a source of new insights in Physics, Biology, Geology, Cosmology, Social Sciences and all intellectual activities which look at the world through the lens of a standard analysis in terms of either Simplicity or Complexity. It will be investigated if and how Complexity could shed new light in the greatest achievement of Reductionism, i.e. the **Standard Model** and its extension which predicts GUT, the existence of the Superworld and the resolution of the quantum-gravity problem via the powerful theoretical structure of RQST (Relativistic Quantum String Theory).

### APPLICATIONS

Interested candidates should send a letter to the Director of the School:

Professor Antonino ZICHICHI  
CERN  
CH-1211 GENEVA 23, Switzerland

Needed:

- date of birth and present activity;
- nationality;
- letter of recommendation from a senior physicist.

To honour the memory of Victor Weisskopf, the **WORLD FEDERATION OF SCIENTISTS** (WFS) has established a commemorative fund to support needy students. Students in need of financial support should apply for this fund, specifying their needs (i.e. participation fee only or also travel expenses) at the time of the application to the School.

#### • PLEASE NOTE

Participants must arrive in Erice on August 29, not later than 5 p.m.

More information about the other activities of the  
"ETTORE MAJORANA" FOUNDATION AND CENTRE FOR SCIENTIFIC CULTURE  
can be found on the WWW at the following address:  
<http://www.cesem.infn.it>

### POETIC TOUCH

According to legend, Erice, son of Venus and Neptune, founded a small town on top of a mountain (750 metres above sea level) more than three thousand years ago. The founder of modern history — i.e. the recording of events in a methodic and chronological sequence as they really happened without reference to mythical causes — the great Thucydides (~500 B.C.), writing about events connected with the conquest of Troy (1183 B.C.) said: «After the fall of Troy some Trojans on their escape from the Achaes arrived in Sicily by boat and as they settled near the border with the Sicilians all together they were named Elymi: their towns were Segesta and Erice.» This inspired Virgil to describe the arrival of the Trojan royal family in Erice and the burial of Anchise, by his son Enea, on the coast below Erice. Homer (~1000 B.C.), Theocritus (~300 B.C.), Polybius (~200 B.C.), Virgil (~50 B.C.), Horace (~20 B.C.), and others have celebrated this magnificent spot in Sicily in their poems. During seven centuries (XIII-XIX) the town of Erice was under the leadership of a local oligarchy, whose wisdom assured a long period of cultural development and economic prosperity which in turn gave rise to the many churches, monasteries and private palaces which you see today. In Erice you can admire the Castle of Venus, the Cyclopean Walls (~800 B.C.) and the Gothic Cathedral (~1300 A.D.). Erice is at present a mixture of ancient and medieval architecture. Other masterpieces of ancient civilization are to be found in the neighbourhood: at Motya (Phoenician), Segesta (Elymian), and Selinunte (Greek). On the Aegadian Islands — theatre of the decisive naval battle of the first Punic War (264-241 B.C.) — suggestive neolithic and paleolithic vestiges are still visible: the grottoes of Favignana, the carvings and murals of Levanzo. Splendid beaches are to be found at San Vito Lo Capo, Scopello, and Comino, and a wild and rocky coast around Monte Cofano: all at less than one hour's drive from Erice.

### DIPLOMAS for the Best Students

The following Diplomas have been established in honour of, and named after, the late physicists:

JOHN S. BELL	GUNNAR KALLEN	BRUNO ROSSI
PATRICK M.S. BLACKETT	YUVAL NEEAMAN	ANDREI D. SAKHAROV
JAMES CHADWICK	GIUSEPPE P.S. OCCHIALINI	VICTOR F. WEISSKOPF
RICHARD H. DALITZ	BRUNO PONTECORVO	EUGENE P. WIGNER
PAUL A.M. DIRAC	ORESTE PICCIONI	BJORN H. WIJK
VLADIMIR N. GRIBOV	ISIDOR I. RABI	CHIEN SHIUNG WU
ROBERT HOFSTADTER	GIULIO RACAH	

These Diplomas will be awarded at the end of the Course by the Board composed of the Lecturers and the Invited Scientists.

**A. ZICHICHI**  
**DIRECTOR OF THE SCHOOL**