

INTERNATIONAL SCHOOL OF SUBNUCLEAR PHYSICS

Director: A. ZICHICHI

53RD COURSE:

THE FUTURE OF OUR PHYSICS INCLUDING
NEW FRONTIER

DIRECTORS: G. 'T HOOFT - A. ZICHICHI

24 JUNE - 3 JULY 2015



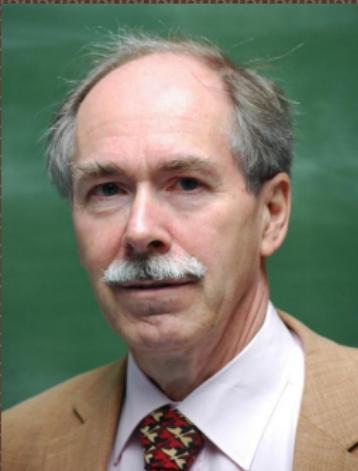
Erice

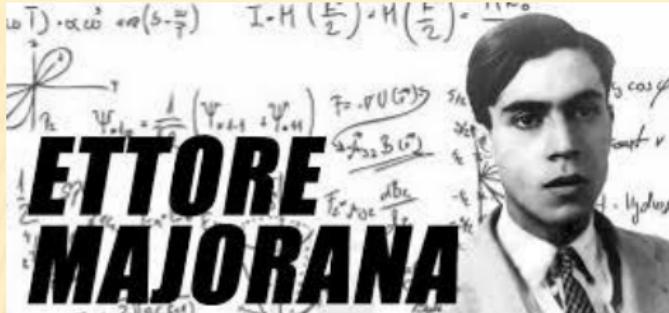




Erice

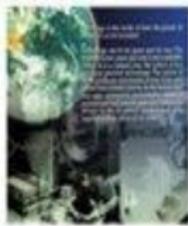
2015 Erice School Directors



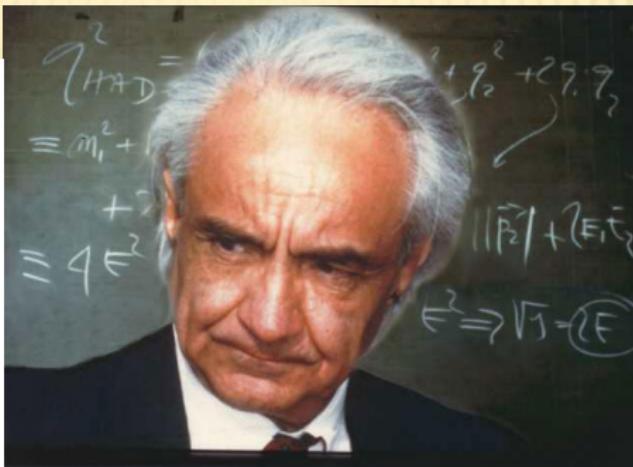


Antonino Zichichi

CREATIVITY IN SCIENCE



World Scientific



Антонио
Дзичичи

Творчество
в науке



Antonino Zichichi



INTERNATIONAL SCHOOL OF SUBNUCLEAR PHYSICS

THE FUTURE OF OUR PHYSICS INCLUDING NEW FRONTIERS

53rd Course – ERICE-SICILY: 24 JUNE – 3 JULY 2015

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 • Italian National Institute for Nuclear Physics • Weizmann Institute of Science • World Federation of Scientists • World Laboratory

PROGRAMME AND LECTURERS

CELEBRATION THE TRIUMPH OF ETTORE MAJORANA

IN SOLID STATE PHYSICS

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

IN SUPERGRAVITY

• S. FERRARA, CERN, Geneva, CH; LNF-INFN, Frascati, IT; UCLA, Los Angeles, CA, US

OPENING SESSION

The Future of our Physics

- A. ZICHICHI, CERN, Geneva, CH; University of Bologna & INFN, IT

THE NEW FRONTIERS

New Physics is needed to understand Black Holes

- G. 't HOOFT, Utrecht University, NL

The CMB multipoles need String Theory with Supersymmetry Breaking

- A. SAGNOTTI, Scuola Normale Superiore, Pisa, IT

Quantum Universe: Theory vs. Observations

- S. MUKHANOV, Sommerfeld Center for Theoretical Physics and Max Planck Institute, Munich, DE

Classification and Selfcompletion of Gravity

- G. D'ALDI, Sommerfeld Center for Theoretical Physics, Munich, DE; NYU, NY, USA

partial Supersymmetry Breaking and Born-Infeld Actions

- S. FERRARA, CERN, Geneva, CH; LNF-INFN, Frascati, IT; UCLA, Los Angeles, CA, US

Spin two equals spin one squared

- M.J. DUFF, Imperial College London, UK

How to Compute the Absolute Masses of Neutrinos

- H. FRITZSCH, Ludwig-Maximilians-Universitaet, Muenchen, DE; Nanyang Technological University, Singapore, SG

Cosmology and Fundamental Physics

- P. FERREIRA, University of Oxford, UK

The LAA impact on technology R&D: From past to future

- H. WENNINGER, CERN, Geneva, CH

Roadmap at the LHC to the Higgs boson and beyond

- P. JENNI, CERN, Geneva, CH; Albert-Ludwigs-University Freiburg, DE

The EEE Project of the Enrico Fermi Centre, Rome, IT

- L. CIFARELLI, INFN & University of Bologna, IT

Neutrino Physics in China

- L. WEN, Institute of High Energy Physics, CAS, Beijing, CN

Latest results from Ice Cube

- F. HALZEN, University of Wisconsin-Madison, WI, USA

HIGHLIGHTS FROM

LHC

- S. BERTOLUCCI, CERN, Geneva, CH

LHCb

- G. WILKINSON, University of Oxford, UK

ALICE

- P. GIUBELLINO, CERN, Geneva, CH; University of Turin, IT

CMS

- G. LANDSBERG, Brown University, Providence, RI, US; CERN, Geneva, CH

ATLAS

- P. JENNI, CERN, Geneva, CH; Albert-Ludwigs-University Freiburg, DE

INFN

- F. FERRONI, INFN, Rome, Italy

High Luminosity LHC Project

- L. ROSSI, CERN, Geneva, CH

BNL and RHIC

- M.J. TANNENBAUM, Brookhaven National Laboratory, Upton, NY, US

AMS

- S. SCHael, I. Physikalisches Institut B, RWTH, Aachen, DE

Confranc Underground Lab, ES

- A. BETTINI, INFN & Padua University, IT

Planck Satellite: Latest Data and Proof of Inflation

- A. RIAZUELO, Institute d'Astrophysique de Paris, FR

CLOSING REMARKS

- G. 't HOOFT, Utrecht University, NL

TEN PROBLEMS OPEN FOR COMPETITION

THE FIRST GROUP: MIXINGS

- *Is there an explanation for the flavour mixing mechanisms?*
- *Why do these mechanisms produce results that differ substantially in the quark and in the lepton sectors?*
- *Why does the mixing of states not exist in any other fundamental interaction?*

THE SECOND GROUP: ELEMENTARY AND COMPOSITE STATES

- *What is the role of instantons in the spectrum of hadrons in QCD? Where are the scalar hadronic states in QCD? Are there scalar states in the leptonic system?*
- *Why are there only fundamental particles with the minimum quark or lepton quantum numbers? Do elementary particles with higher, composite quantum numbers exist?*

- *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 are the global discrete symmetries (C , P , CP , T) explicitly and not spontaneously broken, as it seems to be the case today?*
- *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 to find at LHC any evidence for Supersymmetry).*

INVITED SCIENTISTS

- | | |
|--|---|
| • R. BALDINI FERROLI, INFN-LNF, Frascati, IT; Institute of High Energy Physics, CAS, Beijing, CN | • M. KAUR, Panjab University, Chandigarh, IN |
| • G. BENEDEK, Milano-Bicocca University, Milan, IT | • C. KORTHALS-ALTES, CNRS-Luminy, Marseille, FR |
| • C.A. DOMINGUEZ, University of Cape Town, ZA | • P. MINKOWSKI, University of Bern, CH |
| • M. GELL-MANN, Santa Fe Institute, New Mexico, US | • V.A. PETROV, IHEP, Protvino, RU |
| • D. HAIDT, DESY, Hamburg, DE | • S. RAGAZZI, INFN-GSNL, L'Aquila, IT |
| • P.W. HIGGS, University of Edinburgh, UK | • M. SPIRO, IN2P3, CNRS, Paris, FR |

Цифры

36 профессоров и 136 молодых участников из 28 стран

из них  50 – Россия, 20 – Италия, 18 – Украина

32 лекции, 47 докладов, 18 постеров

50% теория 50% эксперимент

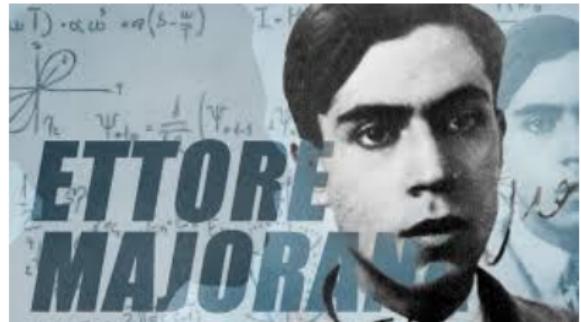
Тематика



Тематика: вопросы к обсуждению

1. **Flavour mixing:** quarks vs leptons? where is fundamental explanation?
2. **Bound states:** where are instantons? do elementary particles with higher spin exists? why there is no fundamental bosons in the same mass range like fermions?
3. **Symmetry breaking:** why CPT broken explicitly, not spontaneously?
where is supersymmetry broken?

Лекции



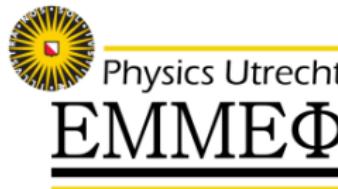
Majorana Fermions in Particle Physics, Solid State and Quantum Information Theory

Michael Duff

25 June 2015, EMFCSC Erice

M Duff: Majorana Fermions in Particle Physics, Solid State Physics and Quantum Information Theory

- Майорановские частицы в НЕР: смешивание нейтрино, seesaw и т.д.
- Майорановские квазичастицы в топологических сверхпроводниках (Majorana Zero Modes (MZM))
 - Удовлетворяют *неабелевой* статистике \Rightarrow перестановка двух квазичастиц приводит к новому состоянию (см. arXiv:1403.4976 [cond-mat])
 - Легко могут быть топологически разделены и являются кандидатами на роль кубитов в квантовых компьютерах (два MZM = 1 фермион \Rightarrow 2 состояния (0 или 1) = 1 кубит)



Spinoza Institute, Center for Extreme Matter and Emergent Phenomena,
Science Faculty, Utrecht University, Leuvenlaan 4, POBox 80.195, 3808TD, Utrecht

New physics is needed to understand black holes

or

*Renormalization of the gravitational force
in analogy with the electroweak theory*

Gerard 't Hooft

Erice, School of Subnuclear Physics

June 26, 27 2015

Программа действий

- Исходный лагранжиан

$$\mathcal{L}(g_{\mu\nu}, A_\mu, \psi, \phi) = \frac{1}{16\pi G} \sqrt{-g} (R - 2\Lambda) + \mathcal{L}^{\text{matter}}$$

- Перейдем к новым переменным:

$$g_{\mu\nu}(x) = \omega^2(x) \hat{g}_{\mu\nu}(x) \Rightarrow \mathcal{L}(\omega, \hat{g}_{\mu\nu}, A_\mu, \psi, \phi)$$

- Добавим для $\hat{g}_{\mu\nu}$ кинетическое слагаемое (конформно инвариантное)

$$\mathcal{L}^{\text{kin}} \sim \sqrt{-\hat{g}} C_{\mu\nu\alpha\beta} C^{\mu\nu\alpha\beta}$$

- Теория перенормируема
- В ней есть дух \Rightarrow нарушение унитарности
- Детерминистическая квантовая механика [*'t Hooft, Found.Phys. 44 (2014) 406-425*]

LHCb highlights

- Flavour physics
 - a topic of intrinsic interest
 - a tool for indirect discovery
- LHCb overview
- *Selected* recent results
 - Rare decays & FCNCs
 - CPV & unitarity triangle tests
 - Spectroscopy & exotics
- Run 2 and the voyage beyond



The cyclops pursuing Acis on Mt Etna

Guy Wilkinson, University of Oxford and CERN, June 2015

LHCb highlights

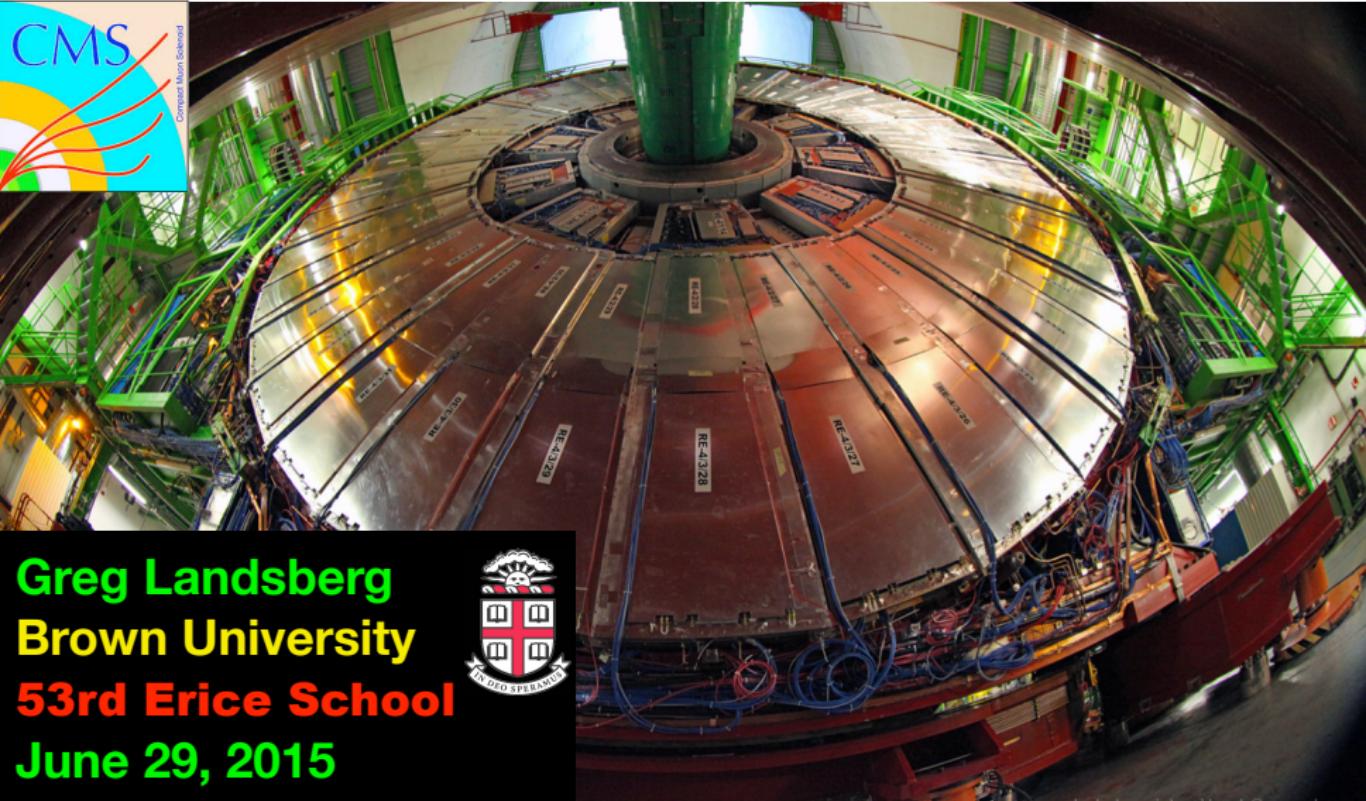
Flavour changing neutral currents (FCNC):

- Отношение ширин $B_s \rightarrow \mu^+ \mu^-$ и $B^0 \rightarrow \mu^+ \mu^-$ укладывается в СМ
- FB-asymmetry в распадах $B^0 \rightarrow K^* \mu^+ \mu^- A_{FB}$ и $B_s \rightarrow \phi \mu^+ \mu^-$ тоже укладывается в СМ, хотя некоторые наблюдаемые ($P5?$) расходятся с предсказаниями СМ (открытый вопрос: вильсоновские коэффициенты)
- CKM измерение (треугольник), все ок
- CPV – ok

RUN2:

- Большой апгрейд детектора
- Уже все работает

HIGHLIGHTS FROM CMS



Greg Landsberg
Brown University
53rd Erice School
June 29, 2015



The plan:

Short history of the LHC

The experiments

Testing/Commissioning the detectors

Comments on computing

The physics landscape

Some physics results

Standard Model

Higgs

Beyond the SM searches

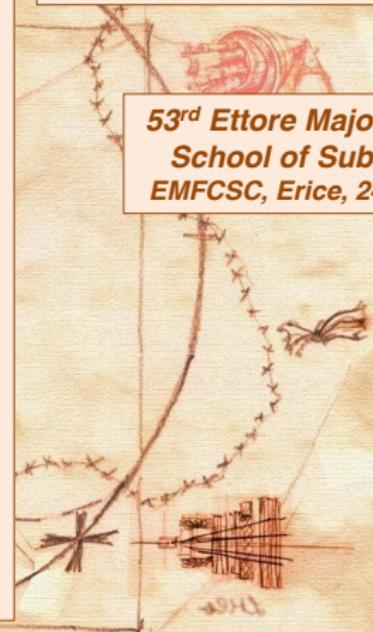
Outlook

(Note that I will use often examples from ATLAS, but the ~same applies for CMS!)

Also, the emphasis is sometimes not on the most up-to-date plots, rather on best illustrations to make a given point)

Roadmap at the LHC to the Higgs Boson and Beyond

**53rd Ettore Majorana International
School of Subnuclear Physics
EMFESC, Erice, 24 June – 3 July 2015**



Drawing by
Sergio Cittolin

Peter Jenni, Freiburg and CERN



**High
Luminosity
LHC**

The High Luminosity LHC Project

Lucio Rossi - CERN

**53rd Course of International School of Subnuclear physics
E. Majorana Center – ERICE, 26 June 2015**



The HiLumi LHC Design Study is included in the High Luminosity LHC project and is partly funded by the European Commission within the Framework Programme 7 Capacities Specific Programme, Grant Agreement 284404.



Quantum Universe

V. Mukhanov
ASC, LMU, München

Classicalization and Self-Completion

Gia Dvali
LMU-MPI & NYU

Cesar Gomez;
+ Alex Kechnias, Cian
Guidice,
...
(ERIC, 2015)

For such systems we can define a quantity

$$(N\alpha)$$

Something very special takes place at

$$N\alpha = 1$$

↑
Critical point of quantum phase transition.

Planck Highlights

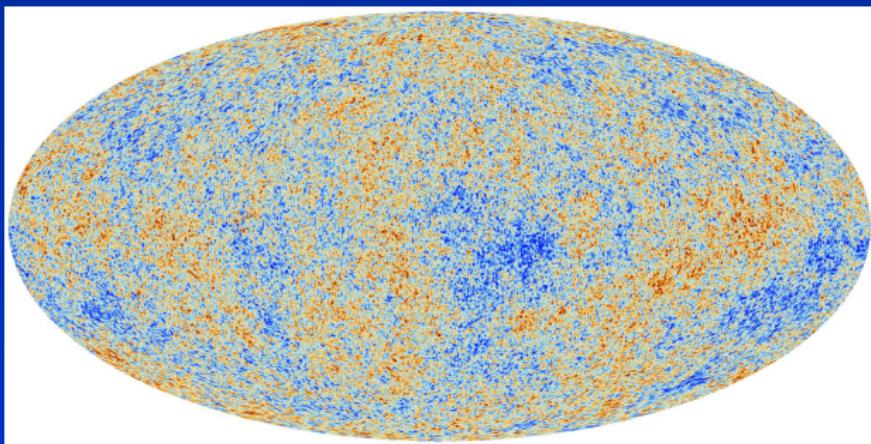
Alain Riazuelo

Institut d'astrophysique de Paris

(and weakly bounded member of the Planck collaboration)

riazuelo AT iap.fr

Erice, 29 June 2015



**FLAVOR MIXING
and
NEUTRINO MASSES**

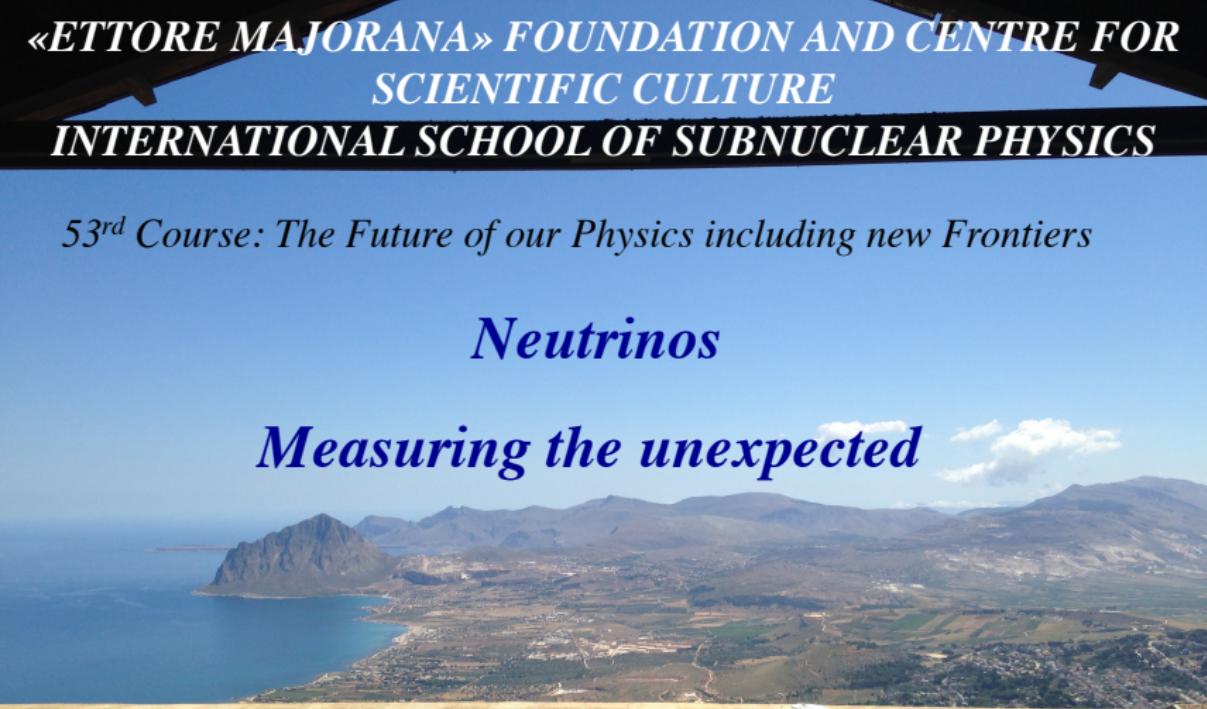
H. FRITZSCH

**«ETTORE MAJORANA» FOUNDATION AND CENTRE FOR
SCIENTIFIC CULTURE**
INTERNATIONAL SCHOOL OF SUBNUCLEAR PHYSICS

53rd Course: The Future of our Physics including new Frontiers

Neutrinos

Measuring the unexpected



A photograph showing a coastal landscape with a large, rugged mountain range in the background. In the foreground, there's a town built along a coastline with a bay. The sky is clear with some wispy clouds.

A. Bettini

G. Galilei Physics and Astronomy Dept. Padua University, Italy

INFN

Доклады



Интересные

- Yaroslav Klopot, “Axial anomaly, vector meson dominance and mixing”
- A. Behring, “Heavy flavor contributions to deep-inelastic scattering at 3-loop order”
- Mykola Savitskyi, “First studies towards top-quark pair differential cross section measurement in the dilepton channel at $\sqrt{s} = 13$ TeV with the CMS detector”
- Emanuele Messina, “Vacuum stability and new physics”

