Frontiers of Fundamental Physics 14

List of speakers in Plenary Sessions

Updated on January 8, 2015

Elena **Amato** (INAF) **July, 17, 11h30 – 12h00, Amphi "Massiani", Plenary Session 2**

Particle acceleration in astrophysical sources

Astrophysical sources are extremely efficient accelerators. Some sources emit photons up to multi-TeV energies, a signature of the presence, within them, of particles with energies much higher than those achievable with the largest accelerators on Earth. Even more compelling evidence comes from the study of Cosmic Rays, charged relativistic particles that reach the Earth with incredibly high energies: at the highest energy end of their spectrum, these subatomic particles are carrying a macroscopic energy, up to a few Joules.

Here I will address the best candidate sources and mechanisms as cosmic particle accelerators. I will mainly focus on Galactic sources such as Supernova Remnants and Pulsar Wind Nebulae, which being close and bright, are the best studied and understood among astrophysical accelerators. These sources are probably responsible only for particle acceleration up to PeV energies, and hence for most of the energy that is put into relativistic particles in the Universe, but not for the highest individual particle energies. However they allow us to study in great detail acceleration mechanisms such as shock acceleration (both in the newtonian and relativistic regime) or magnetic reconnection, the same processes that are likely to be operating also in more powerful sources.

Pierre **Astier** (LPNHE) **July, 15, 12h00 – 12h30, Amphi "Sciences Naturelles", Plenary Session 1**

Distances to supernovae: an efficient probe of dark energy

Measuring distances to supernovae (or more precisely to the "type Ia" subclass) has allowed us to measure the distance-redshift relation beyond linear order for the first time in 1998. These first results already showed strong evidence for an accelerated cosmological expansion at the present epoch. This has been confirmed by several other cosmological probes, but what causes this accelerated expansion remains elusive. Our ignorance is commonly parametrized using the "equation of state of dark energy", where dark energy refers to the fluid one can postulate to source the acceleration. I will present how supernova measurements have evolved since the discovery, review the latest dark energy constraints, and discuss the future of the probe.

Veniamin **Berezinsky** (GSSI) **July, 18, 12h00 – 12h30, Amphi "Massiani", Plenary Session 2**

UHECR: Progress and Problems

Three fundamental problems in the field of UHE astrophysical particles are reviewed.

UHE particles are observed at energies higher than 1×10^{20}eV, with 3×10^{20}eV as the highest energy. In principle, in cosmology there are the reliable mechanisms of particle production with energies much higher than 10^{20}eV (e.g. Topological Defects or Super Heavy Dark Matter), but this production most probably cannot explain the observational data. It is widely argued nowadays that traditional acceleration, e.g. acceleration by relativistic shocks, cannot provide the observed highest energies.

The other fundamental problem is propagation of protons and nuclei in extragalactic space. This problem is studied thoroughly theoretically with prediction of spectral features, dip and GZK cutoff, for protons, which are observed in data of HiRes and Telescope Array, but contradict to mass composition measured by of Auger.

The third fundamental problem is cosmogenic neutrinos, produced by interaction of UHE protons and nuclei with background radiation CMB and EBL. Neutrinos detected by IceCube in 2010 - 2012 do not correspond to standard predictions, and detection of cosmogenic neutrinos probably expects the future space detector JEM-EUSO.

Eugenio **Bianchi** (Penn State) **July, 15, 11h45 – 12h30, Amphi "Charve", Plenary Session 3**

Last gasps of a black hole

After 40 years of active research the question of the fate of information that falls into a black hole is still open [1]. In this talk I will discuss recent results [2] that allow us to compute the entanglement entropy production in black hole evaporation. In particular I present a study of the information release in a model that takes into account the loop quantum gravity resolution of the black hole singularity [3]. The analysis of this phenomenon provides new insights into the entanglement structure of space-time during and after the complete evaporation of the black hole.

References

[1] S.W. Hawking, *Breakdown of predictability in gravitational collapse*, Phys. Rev. D **14** (1976) 10, 2460.

[2] E. Bianchi and M. Smerlak, *Entanglement entropy and negative-energy fluxes in two-dimensional spacetimes*, (2014), arXiv:1404.0602

[3] C. Rovelli and F. Vidotto, *Planck stars*, (2014), arXiv:1401.6562

Pierre **Bieliavsky** (UCLouvain) **July, 15, 11h45 – 12h30, Amphi "Massiani", Plenary Session 2**

Geometrical aspects of deformation quantization

This talk will be an introduction to deformation quantization based on geometrical considerations. I will show how the notion of $*$-product emerges from a formula for the multiplication of matrices. I will then give a definition of deformation quantization in the context of Poisson manifolds and conclude by general results about this notion. The talk is meant to a general audience.

Jean-Paul **Blaizot** (IPhT) **July, 18, 11h30 – 12h00, Amphi "Massiani", Plenary Session 2**

Recent experimental results and theoretical developments in Heavy Ion physics

Ultra-relativistic heavy ion collisions allow us to study the densest and hottest forms of matter that can be created in the laboratory, states of matter that have existed in the early universe for only a brief instant, a few microseconds after the big bang.

In this talk, I shall present a short overview of the latest developments in the field, by choosing a few highlights from the results obtained at the LHC. I shall also discuss the evolution of ideas and concepts that have been triggered by these experiments.

François **Bouchet** (IAP) **July, 16, 09h00 – 09h45, Amphi "Sciences Naturelles", Plenary Session**

Cosmological results from Planck and LSS

Sketched out in 1992, selected by ESA in 1996, launched in 2009, Planck delivered on March 21st its first full sky maps of the millimetric emission at 9 frequencies, as well as those which follow from them, and in particular Planck map of the anisotropies of the Cosmic Microwave Background (CMB). The later displays minuscule variations as a function of the observing direction of the temperature of the fossile radiation around its mean temperature of 2.725K. I will briefly describe how these high resolution maps with a precision of a few parts in a million have been obtained, from collection to analysis of the first 500 billion samples of our HFI instrument.

CMB anisotropies reveal the imprint of the primordial fluctuations which initiate the growth of the large scale structures of the Universe, as transformed by their evolution, in particular during the first 370 000 years, i.e. till the Universe became transparent and the forming of the image we record today. The statistical characteristics of these anisotropies allow constraining jointly the physics of the creation of the primordial fluctuations and that of their evolution. They teach us the possible value of the parameters of the models which we confront to data. I will describe Planck estimates of the density of the constituents of the Universe (usual matter, cold dark matter or CDM, dark energy...), and their implication in terms of derived quantities like the expansion rate or the spatial curvature. I will review what we learnt on the generation of the fluctuation, and wil discuss extensions of the standard cosmological model, so called "Lambda-CDM", both in term of non minimal physical models – multi-field inflation for instance, or additional constituents - like cosmic strings or a fourth neutrino.

Finally, it will briefly describe other promising results on the matter distribution which is travelled through by the CMB image on its long 13.7 billion years trip towards us. I will mention in particular what we can learn on the dark matter distribution - which is detected through its distorting effet of the CMB image by gravitationnal lensing, or that of hot gaz, which is revealed by the spectral distortion it induces.

Philippe **Brax** (IPHT) **July, 18, 11h00 – 11h30, Amphi "Sciences Naturelles", Plenary Session 1**

Dark Energy and Modified Gravity

I will review some of the recently uncovered connections between dark energy and modified gravity. Dark energy involves light scalar fields which would naturally lead to deviations from Newton's law in the solar system. Those are extremely constrained by gravity tests. I will present how one can reconcile dark energy on large cosmological scales with gravity as tested in the solar systems. For that, I will introduce screened modified gravity models and discuss their properties.

Ali **Chamseddine** (AUB and IHES) **July, 15, 11h00 – 11h45, Amphi "Massiani", Plenary Session 2**

Geometric Unification

I will show that Noncommutative Geometry provides an appealing framework for the unification of all fundamental interactions including gravity

Cédric **Deffayet** (IAP and IHÉS) **July, 18, 11h30 – 12h00, Amphi "Sciences Naturelles", Plenary Session 1**

From DGT to dRGT: a review of "massive gravity" theories

Motivated in part by the wish to "replace" dark energy by a large distance modification of gravity, a large body of works has lead to a better understanding of properties and pathologies of theories of "massive gravity", and closely related models such as "Galileons". This body mainly developped from the Dvali-Gabadadze-Porrati (DGP) model which was proposed almost 15 years ago - and was the first framework which linked explicitly the cosmic acceleration with a large distance modification of gravity - and culminated with the more recent de Rham-Gabadadze-Tolley (dRGT) theory which is now believed to avoid certain pathologies present in previous constructions. Inbetween, these works also lead to several other proposals, many of which using the "Vainshtein mechanism" to hide at intermediate distances effects which only show up at cosmological scales. I will review these works stressing in particular the left over open questions.

Enrique **Gaztañaga** (ICE, IEEC-CSIC) **July, 15, 11h00 – 11h30, Amphi "Sciences Naturelles", Plenary Session 1**

LSS with angular cross-correlations: Combining Spectroscopic and Photometric Surveys

The search for the nature of the dark sector relies on the combination of multiple techniques and probes, from both spectroscopic and photometric data. This matches well with the fact that some probes are intrinsically 3D (like RSD) and some 2D (like WL). But to get the best constraints we need to combine all of these. We show how using angular cross-correlations we can recover the full 3D galaxy clustering information, including BAO and RSD in spectroscopic surveys. This allows the combination of spectroscopic and photometric galaxy surveys, including photo-z error calibration and addition of WL. We show some application of these ideas in current data and simulations and show how overlapping surveys result in both better constrains and better understanding of systematic errors.

Walter **Greiner** (FIAS) **July, 15, 11h00 – 11h45, Amphi "Charve", Plenary Session 3**

There are no black holes: Pseudo-Complex General Relativity From Einstein to Zweistein

General Relativity - in particular if applied to the central mass problem – contains a singularity: The Schwarzschild singularity, which leads to the prediction of black holes.

Our new concept is: No theory should contain singularities. This will also be applied to quantum electrodynamics: In General Relativity it leads us to Pseudo-Complex General Relativity. Black holes disappear and a new "Weltbild" for the cosmos emerges.

Luigi **Guzzo** (INAF - OA Brera) **July, 16, 12h00 – 12h30, Amphi "Charve", Plenary Session 1**

Cosmology with Galaxy Redshift Surveys

After more than fifteen years, the discovery that the Universe is accelerating emerges as one of the turning points in the history of cosmology, as witnessed by the 2011 Nobel Prize in Physics to Perlmutter, Riess and Schmidt. Yet, the origin of the accelerated expansion is a mystery. One possibility is that the Universe is permeated by a "dark energy" producing a kind of gravitational repulsion. Alternatively, perhaps the very equations of General Relativity need to be modified or generalized to higher-dimensional worlds.

Galaxy redshift surveys are one of the experimental pillars that contributed significantly to build this overall scenario and even larger projects are ongoing or planned, with the goal of understanding the nature of cosmic acceleration. In my talk I will review this situation and show how redshift surveys allow us to possibly break the degeneracy between dark energy and modified gravity by measuring both the expansion rate and the growth rate of structures. I will present recent examples, including results from the new VIPERS survey at the ESO Very Large Telescope. I will then discuss status and plans for the ultimate dark-energy experiment , the ESA satellite Euclid, which is due to launch in 2020. Euclid promises to reach percent accuracies on the measurement of cosmological parameters, with unprecedented control of systematic effects.

Francis **Halzen** (WIPAC) **July, 16, 12h00 – 12h30, Amphi "Sciences Naturelles", Plenary Session 2**

IceCube and the Discovery of High-Energy Cosmic Neutrinos

The IceCube project has transformed one cubic kilometer of natural Antarctic ice into a neutrino detector. The instrument detects 100,000 neutrinos per year in the GeV to PeV energy range. Among those, we have recently isolated a flux of high-energy cosmic neutrinos. I will discuss the instrument, the analysis of the data, and the significance of the discovery of cosmic neutrinos.

Alan **Heavens** (ICIC) **July, 16, 11h00 – 11h30, Amphi "Charve", Plenary Session 1**

Weak gravitational lensing

Weak gravitational lensing by inhomogeneities along the line-of-sight alters the shapes, sizes and fluxes of distant sources such as galaxies, and distorts the pattern of continuous fields such as the microwave background radiation. In this talk I will review this relatively young scientific field, with particular emphasis on its power for studying dark energy and modified gravity. I will discuss the challenges it faces, summarize results from recent survey analyses, and finally consider the prospects for the future

Christian **Hoelbling** (Bergische Universität Wuppertal) **July, 17, 11h00 – 11h30, Amphi "Massiani", Plenary Session 2**

Physical predicions from lattice QCD

Lattice QCD is a method for solving the nonperturbative dynamics of low energy QCD from first principles. Over the last few years, the field has matured considerably and reliable experimental predictions have been obtained in many areas. I will summarise the most important developments, give an overview of the currently attainable precision on key observables such as the hadron spectrum or the light quark masses and discuss some open challenges and future perspectives of the field.

Kazuya **Koyama** (UoP) **July, 18, 12h00 – 12h30, Amphi "Sciences Naturelles", Plenary Session 1**

Cosmological tests of gravity

The discovery of the accelerated expansion of the Universe has come relatively late in our study of the cosmos, but in showing that gravity can act repulsively, it has opened up many new questions about the nature of gravity and what the Universe might contain. Is the acceleration being driven by dark energy? Or is general relativity (GR) itself in error, requiring a modification at large scales to account for the late acceleration? Structure formation in our Universe can be different even if the geometry of the homogeneous and isotropic universe is the same in these two classes of models, offering a possibility to distinguish between them observationally. Non-linear structure formation is complicated by the fifth force that commonly appears in modified gravity models and new techniques are required to analyse it. We will discuss novel methods to test GR on cosmological scales, building on the recent developments of N-body simulations for modified gravity.

Jerzy **Lewandowski** (UW) **July, 17, 11h00 – 11h45, Amphi "Sciences Naturelles", Plenary Session 3**

Background independence of GR and in LQG

The physical meaning of the diffeomorphisms in the general relativistic theories will be discussed, the issues of time evolution in terms of the Dirac observables and physical Hamiltonian will be addressed. New proposals for geometric deparametrization will be presented. The quantum part of the lecture will concern the canonical LQG. New, improved formulations of the quantum Hamiltonian will be proposed. New applications for LQG will be offered. Original results that will be presented in this lecture were obtained in collaboration with: Dapor, Duch, Kaminski, Swiezewski, Alesci, Assanioussi, Dziendzikowski and Sahlmann.

Fabio **Maltoni** (CP3) **July, 16, 11h30 – 12h00, Amphi "Sciences Naturelles", Plenary Session 2**

The top-quark gateway to new physics

The top quark is the only fermion whose mass resides at the electroweak scale. Its role in the SM and in models of new physics together with its rich phenomenology provide a unique opportunity for exploring the TeV scale. In this talk I review the status of top-quark measurements after the Run I of the LHC and the exciting opportunities ahead in light of the possibility for the top quark to be a portal to new physics.

Jérôme **Martin** (IAP) **July, 17, 12h00 – 12h30, Amphi "Charve", Plenary Session 1**

Inflation after Planck & BICEP2

The inflationary scenario is currently considered to be the most promising paradigm to describe the origin of the perturbations in the early universe. It corresponds to a period of accelerated expansion before the hot Big Bang phase. Inflation is typically achieved using scalar fields, and it is the quantum fluctuations associated with the scalar fields that are responsible for the creation of the primordial perturbations. The perturbations generated during inflation leave their signatures as anisotropies in the Cosmic Microwave Background (CMB). With the CMB anisotropies being measured to greater and greater precision, we are presently in an unprecedented situation of being able to arrive at strong constraints on the physics of the early universe. In this talk, after a brief introduction to inflation, I describe the implications of the recently released Planck & BICEP2 data for inflation and discuss what are the "best" inflationary scenarios.

References

[1] J. Martin, C. Ringeval and V. Vennin, *Encylopedia Inflationaris*, to appear in Journal of the dark universe [arXiv:1303.3787].
[2] J. Martin, C. Ringeval, R. Trotta and V. Vennin, *The Best Inflationary Models after Planck*, JCAP1403, 039, 2014, [arXiv:1312.3529].
[3] J. Martin, C. Ringeval and V. Vennin, *K-inflationary Power Spectra at Second Order*, JCAP1306, 021, 2013, [arXiv:1303.2120].

Sabino **Matarrese** (UNIPD) **July, 17, 11h30 – 12h00, Amphi "Charve", Plenary Session 1**

Primordial non-Gaussianity, present status and future prospects

I will review both the general problem of the search for non-Gaussian signatures in cosmological perturbations, originated from inflation in the early Universe. I will discuss this issue both from the theoretical point of view and in connection with constraints coming from recent observations and future prospects for observing/constraining them.

Federico **Mescia** (UB) **July, 17, 12h00 – 12h30, Amphi "Massiani", Plenary Session 2**

Review of Flavour Physics

I will present a summary of what we learned so far from low-energy flavor observables, concerning on physics beyond the Standard Model (SM). In the past few years there has been a great experimental progress in quark and lepton flavour physics. In the quark sector, the validity of the SM has been strongly reinforced by a series of challenging tests. As I try to show, looking for physics beyond the SM via the Flavour Window is still a powerful tool thanks also to forthcoming results from LHC and future B Factories.

Adi **Nusser** (IIT) **July, 15, 11h30 – 12h00, Amphi "Sciences Naturelles", Plenary Session 1**

Dynamics of the Cosmic Web

A critical assessment of the observed large scale structure will be presented, starting from the Local Group of galaxies within 5 Mpc, out to $z \sim 0.1$. Traditional and new probes will be shown to support the standard paradigm of structure formation, but not without raising a few eyebrows. Mild tweaks will be discusses as well as potential constraints on alternative theories of gravity.

Guy **Pelletier** (IPAG) **July, 18, 11h00 – 11h30, Amphi "Massiani", Plenary Session 2**

Relativistic outflows from compact objects and generation of Astroparticles

The relativistic ejections of plasmas from black hole environments and pulsars lead to the production of High energy radiations and cosmic rays, possibly ultra high energy cosmic rays up to a few 1020 eV, through a special kind of shocks. A special kind of self-sustaining, nonlinear structure, called collisionless relativistic shock, will be presented, which is considered as explaining the high energy phenomena as the interplay of a front made of an electromagnetic barrier, the generation of a very intense magnetic turbulence and the generation of a population of high energy particles. Numerical simulations, theoretical developments and possible experiments at powerful laser facilities of these relativistic collisionless shocks have stimulated a significant progress in high energy astrophysics nowadays.

References

[1] A. Spitkovsky, 2008, ApJ, 673, L39
[2] I. Plotnikov, G. Pelletier, M. Lemoine, 2013, MNRAS, 430, 1280
[3] M. Lemoine, G. Pelletier, L. Gremillet, I. Plotnikov, 2014, MNRAS, 440, 1365

Stefan **Pokorski** (FUW) **July, 16, 09h45 – 10h30, Amphi "Sciences Naturelles", Plenary Session**

Status of the BSM scenarios

The two main messages from the LHC, after its first phase, are the discovery of the Higgs-like particle and no evidence for any BSM physics. This stunning, continuous, success of the SM up to the mass scales of order 0(1 TeV) is very puzzling. Although with the discovery of the Higgs particle, the SM is a consistent theory that can be extrapolated up to the Planck scale, it leaves unanswered several well known experimental and theoretical questions. In particular, the naturalness of the weak scale as the guiding principle for BSM physics is now somewhat challanged. From the historical perspective, the concept of naturalness in particle physics is a crucial issue and it should not be abandoned too quickly. After the lessons from the LHC, supersymmetry still remains to be the leading candidate for BSM physics. Other BSM scenarios and the near term experimental prospects for discovering supersymmetric or non-supersymmetric BSM physics will also be briefly reviewed.

Vladimir **Ptuskin** (IPST) **July, 17, 10h00 – 10h30, Amphi "Sciences Naturelles", Plenary Session**

Origin of Cosmic Rays

Brief overview of the current status and prospects of cosmic ray studies is presented. Our Galaxy and extragalactic space are filled with cosmic rays, a relativistic gas of high-energy protons, electrons, and heavy nuclei. The directly measured cosmic ray energy spectrum extends from about 1 MeV to energies above 10^{20} eV. The radio-astronomical, X-ray, gamma-ray and the first very high energy neutrino observations shed light on the origin of cosmic rays. The model of cosmic ray origin in supernova remnants (including pulsars), the interpretation of Voyager data on low energy particles, the structure of knee in cosmic ray spectrum at 3×10^{15} eV, and the energy limit of Galactic sources are discussed. The origin of cosmic rays with energies above 10^{17} to 10^{18} eV may be associated with the Active Galactic Nuclei, the progenitors of Gamma-Ray Bursts, the fast spinning newborn pulsars, the large-scale structure formation shocks and some other objects.

Jorge **Pullin** (LSU) **July, 16, 11h00 – 11h45, Amphi "Massiani", Plenary Session 3**

Hawking radiation in loop quantum gravity

We exploit the recently found exact solution of the quantum constraints of loop quantum gravity in vacuum with spherical symmetry to analyze a quantum field theory living on the quantum space time. The main effect of the quantum background is to lead to field equations that are discrete for the quantum field theory. The Hartle-Hawking, Unruh and Boulware vacua are all recovered with small modifications, but the discrete structure eliminates all infinities asssociated with physical quantities computed on the vacuum. We also briefly address the issue of Lorentz invariance and the emergence of limitations on the matter content of the theory.

References

[1] R. Gambini, J. Pullin, arXiv: 1312:3595, to appear in CQG.

Carlo **Rovelli** (CPT) **July, 17, 09h00 – 09h30, Amphi "Sciences Naturelles", Plenary Session**

Loop Quantum Gravity

I give a general overview of the developments in Loop Quantum Gravity and I describe a recent idea for a possible novel window of observation of quantum gravitational phenomena: Planck stars.

Subir **Sarkar** (UOXF & NBI) **July, 15, 10h00 – 10h30, Amphi "Sciences Naturelles", Plenary Session**

Discovering dark matter

Much effort has been devoted to the study of weak scale particles, e.g. supersymmeteric neutralinos, which have a relic abundance from thermal equilibrium in the early universe matching that of the dark matter. This does not however provide any connection to the comparable abundance of *asymmetric* baryons, which must have a non-thermal origin. 'Dark baryons' from a hidden sector with a similar asymmetry and mass of $\mathcal{O}(5)$ GeV would naturally provide the dark matter. Low-threshold direct detection experiments are required to find such particles, while monojet searches at colliders provide a complementary probe.

Burra **Sidharth** (BMBSC) **July, 16, 11h45 – 12h30, Amphi "Massiani", Plenary Session 3**

A Test Bed for High Energy Physiscs

We briefly comment upon the parallel between graphene and high energy fermions and explore the possibility of using the former as a test bed for the latter rather like Reynold's numbers in a wind tunnel. We also point out that there are parallels to Quantum Gravity approaches, which indeed provide a novel explanation for such effects as the FQAE.

Joe **Silk** (IAP) **July, 18, 10h00 – 10h30, Amphi "Sciences Naturelles", Plenary Session**

Issues in Galaxy Formation 2014

The origin of the galaxies represents an important focus of current cosmological research, both observational and theoretical. Its resolution involves a comprehensive understanding of star formation and evolution, galaxy dynamics, supermassive black holes, and the cosmology of the very early universe. I will review our current understanding of galaxy formation and describe some of the challenges that lie ahead. Specific issues that I will address include the star formation rate in galaxies and the galaxy luminosity function, including the role of feedback.

David **Spergel** (Princeton) **July, 16, 11h30 – 12h00, Amphi "Charve", Plenary Session 1**

The Signature of Low Redshift Large-Scale Structure in the Cosmic Microwave Background

As microwave background photons propagate from the surface of last scatter to our telescopes, they are affected by four distinct processes in the low redshift universe: gravitational lensing, the thermal Sunyaev-Zeldovich (tSZ) effect, the kinematic Sunyaev Zeldovich (kSZ) effect and the intervening Sachs Wolfe effect (ISW). This talk will focus on the kSZ and ISW effect. I will discuss the cross-correlations between the large-scale distribution of galaxies and these two effects and show how current and future measurements can be used to probe the growth rate of structure and gravitational physics on large-scales.

Paraskevas **Sphicas** (CERN and Athens) **July, 15, 09h30 – 10h00, Amphi "Sciences Naturelles", Plenary Session**

Status of HEP after the LHC Run 1

In the past 20 years, the Standard Model (SM) of elementary particles and their interactions has provided an unfailing and remarkably accurate description of all experiments with and without high-energy accelerators, establishing that we understand the physics of the very small up to energy scales of 100 GeV. The Large Hadron Collider of CERN, and its experiments, were conceived to probe the physics of the next frontier, that of the TeV energy scale. True to their charge, the experiments have delivered hundreds of significant and often beautiful measurements, along with the discovery of what looks like the first fundamental scalar particle. The triumph of the Standard Model is complete, especially since no new signal has emerged from the intense searches for "new physics" — yet. The field is now at a crossroads: the existence of a Higgs boson opens a new set of questions, while the evidence, both direct and indirect, that there physics beyond the SM does exist, is still strong and convincing. The talk will present a broad-brush picture of how Run 1 of the LHC has shaped the field of High Energy Physics; along with why expectations are still so very high.

John **Stachel** (CES) **July, 18, 09h30 – 10h00, Amphi "Sciences Naturelles", Plenary Session**

It Ain't Necessarily So: Interpretations and Misinterpretations of Quantum Theory

The *traditional view* is that a theory is a conceptual framework providing predictions, and the results of experiments or observations decide whether the theory is right or wrong. It will be contrasted with the *modern view* that one must incorporate the conditions of applicability of a concept into the very meaning of the concept (*measurability analysis*), and that only a series of theories (*scientific research program*) can be said to be scientific or unscientific. This modern view will be applied to a number of questions in quantum mechanics (*what is quantization?, states vs processes, open vs closed systems*) and quantum field theory (*particles and field quanta, bosons vs fermions*), and to the search for a theory of quantum gravity (*background independent vs fixed background theories*).

Alexei **Starobinsky** (Landau ITP) **July, 17, 09h30 – 10h00, Amphi "Sciences Naturelles", Plenary Session**

Investigating inflation and super-high-energy physics with new CMB data

The measurement of a small deviation of the primordial spectrum of scalar (density) perturbations in the Universe from the exactly flat (Harrison-Zeldovich, $n_s = 1$) one in the WMAP and Planck CMB experiments confirms the general prediction of the early Universe scenario with the de Sitter (inflationary) stage preceding the radiation dominated stage (the hot Big Bang) and strongly restricts the class of viable inflationary models [1].Thus, the status of the inflationary paradigm is changing from "proving" it in general and testing some of its simplest models to applying it for investigation of the actual history of the Universe in the remote past and particle physics at super-high energies using actual observational data. The announced discovery of primordial gravitational wave background through the measurement of the B-mode of the CMB linear polarization in the range of multipoles $\ell = 50 - 150$ in the BISEP2 experiment [2] confirms another general prediction [3] of this scenario, as well as produces the direct evidence for the existence of a very strongly curved space-time with $H \sim 10^{-5} M_{Pl}$ in the past of our Universe and the necessity of quantization of gravitational waves. Still the BISEP2 result is partially contaminated by foregrounds (mainly by polarized galactic dust emission) and requires confirmation of its blackbody character. Moreover, comparison of BISEP2 data with the temperature and E-mode polarization data earlier obtained in the WMAP and Planck experiments shows that the inflationary stage is not so simple and may not be described by a one-parametric model. In particular, the primordial spectrum of scalar perturbations generated during inflation is not of a power-law form [4], mainly due to the $\sim 10\%$ depression of the angular anisotropy power spectrum in the multipole range $\ell = 20 - 40$. A class of models describing this feature which implies existence of some scale (i.e. new physics) during inflation is proposed [5]. Furthermore, account of additional wiggles in the spectrum at $\ell \approx 22$ and $\ell \approx 40$ requires further complication of the inflaton potential [6] by introducing sharp features of the type suggested by previous studies [7]. While viable inflationary models with a smooth potential require the inflaton mass $m \sim 10^{13}$ GeV, it has to increase up to $H \sim 10^{14}$ GeV and may be larger near the feature. Thus, combination of CMB temperature anisotropy and polarization data helps to make a "tomographic" study of inflation and particle physics in this range of energies.

References

[1] P. A. R. Ade et al. [Planck Collaboration], arXiv:1303.5082.
[2] P. A. R. Ade et al. [BISEP2 Collaboration], arxiv:1403.3985.
[3] A. A. Starobinsky, JETP Lett. 30, 682 (1979).
[4] D. K. Hazra, A. Shafieloo, G. F. Smoot and A. A. Starobinsky. JCAP 1406, 061 (2014), arXiv:1403.7786.
[5] D. K. Hazra, A. Shafieloo, G. F. Smoot and A. A. Starobinsky, arXiv:1404.0360.
[6] D. K. Hazra, A. Shafieloo, G. F. Smoot and A. A. Starobinsky, arXiv:1405.2012.
[7] A. A. Starobinsky, JETP Lett. 55, 489 (1992).

Roland **Triay** (CPT) **July, 15, 08h45 – 09h00, Amphi "Sciences Naturelles", Plenary Session**

Opening

Jose W.F **Valle** (IFIC) **July, 16, 11h00 – 11h30, Amphi "Sciences Naturelles", Plenary Session 2**

Neutrino pathways to cosmology

The theoretical and phenomenological status of neutrino physics is reviewed as well as the cosmological implications for dark matter, inflation and the baryon asymmetry.

Gabriele **Veneziano** (CdF) **July, 15, 09h00 – 09h30, Amphi "Sciences Naturelles", Plenary Session**

Personal reflections on two success stories

I will share some personal thoughts prompted by the recent experimental confirmations of the standard model of particle physics and of the so-called concordance model of cosmology.

Laurence **Viennot** (SPC & LDAR) **July, 18, 09h00 – 09h30, Amphi "Sciences Naturelles", Plenary Session**

Co-development of conceptual understanding and critical attitude: an essential condition for physics learning

Since nearly two decades, a decline of interest in scientific studies has entailed the choice of new objectives for science teaching in many countries. To put it briefly, affective factors like motivation and the development of competencies, for instance critical analysis, have received much attention, as well as new approaches to teaching, like Inquiry Based Science Education. Although multiple learning benefits are invoked in each case, also for the future citizen, there is often, *de facto*, a trend toward less conceptual development and structuring, be it in teaching objectives or in students' achievements. I will briefly discuss the risks of oversimplification and teaching rituals in physics, and the need for developing a critical stance in students. I will then discuss, based on two investigations at upper secondary or university level (hot air balloon, radio carbon dating), the idea that a competence like critical analysis should not be envisaged separately from a minimum conceptual development. The final discussion will bear on implications for teaching.

A second part of this talk will be given in a session about physics education: From a subtractive to multiplicative approach, two concept-driven interactive pathways on the selective absorption of light.

David **Wands** (ICG) **July, 17, 11h00 – 11h30, Amphi "Charve", Plenary Session 1**

Cosmic inflation and primordial structure

Cosmic inflation in the very early universe provides a framework in which to understand the seeds of large-scale structure in our Universe. A rapid, accelerated expansion at ultra-high energies can stretch quantum vacuum fluctuations up to extra-galactic scales. I will discuss the impact of recent observations of the cosmic microwave background sky which provide evidence of primordial density perturbations and now, for the first time, possible evidence for primordial gravitational waves as predicted by inflation. I will discuss how inflation compares with alternative models for the origin of structure and how we might further test the physics of inflation through cosmological observations.

References

[1] M. Anselmino, A. Efremov and E. Leader,*The theory and phenomenology of polarized deep inelastic scattering*, ys. Rept. 261 (1995) 1 [Erratum ibid 281 (1997) 399] [hep-ph/9501369].
[2] R. Penrose and W. Rindler, Spinors and Space-time, Vol. 2: Spinor and twistormethods in space-time geometry, Cambridge University Press, Cambridge U.K.(1986), pg. 501.

Bernard **Whiting** (UF) **July, 17, 11h45 – 12h30, Amphi "Sciences Naturelles", Plenary Session 3**

High precision gravitational self-force calculations and post-Newtonian implications

This talk is based on [1,2,3]. Until less than 10 years ago, post-Newtonian (pN) analysis was the only possible systematic method for obtaining gravitational waveforms corresponding to binary inspiral. However, these were cut-off before the merger, until the recent availability of direct results from numerical relativity computations, which could include the complete merger and ring-down phase of the orbital evolution. Unfortunately these calculations are not yet of sufficient precision to strenuously test pN methods intrinsically. By contrast, the gravitational self-force approach has become capable of advancing to extremely high precision, and of thereby testing most of the various techniques used in pN calculations. Although restricted to the extreme-mass-ratio limit, self-force calculations are now able to verify both the methods and results of pN work, and even of extending it. In fact, as will be demonstrated, they now have high enough precision to be able to determine new coefficients analytically.

References

[1] Abhay G Shah, John L Friedman and Bernard F Whiting, *Finding high-order analytic post-Newtonian parameters from a high-precision numerical self-force calculation*, 7pp, published in Phys.Rev. D **89** 064042 (March 18, 2014), arXiv:1312.1952 [gr-qc]
[2] Luc Blanchet, Guillaume Faye and Bernard F. Whiting, *Half-integral conservative post-Newtonian approximations in the redshift factor of black hole binaries*, 12 pp, published in Phys.Rev. D **89** 064026 (March 11, 2014), arXiv:1312.2975 [gr-qc]
[3] Luc Blanchet, Guillaume Faye and Bernard F. Whiting, *High-order half-integral conservative post-Newtonian coefficients in the redshift factor of black hole binaries*, 33 pp, submitted to Phys.Rev. D (May 20, 2014), arXiv:1405.5151 [gr-qc].