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### ASTROPARTICLE PHYSICS IN EUROPE

Interview with Stavros Katzanevas, Chairman of the General Assembly of APPEC\* (AstroParticle Physics European Consortium) with the responsibility for the coordination and funding of national research efforts in astroparticle physics.

#### **Astroparticle physics is a relatively new research field ...**

Astroparticle physics was born at the intersection of astrophysics, particle physics and cosmology. It had multiple origins: the movement towards underground laboratories to study the decay of the proton and neutrino properties, the first detection of high energy photons using particle physics methods, the large surveys searching for astronomical dark matter. Today it addresses the physics of primordial Universe, the nature of dark matter and dark energy; the eventual unification of fundamental interactions; the properties of neutrinos and their role in cosmic evolution; the origin of cosmic rays; the Universe at extreme energies studied using multi-messenger probes including high energy cosmic rays, photons, neutrinos and gravitational waves.

After the Higgs discovery, with the measurement of neutrinos oscillations and the precision results the PLANCK satellite, we have for the first time the theoretical and experimental possibility to formulate a coherent picture of the Universe covering a multitude of energy scales: from the electroweak symmetry breaking scale, or Higgs scale if you wish, to this of inflation.

#### **Which priorities has APPEC set for the next future and which short or long term results can we expect?**

The APPEC Scientific Advisory Committee, under the chairmanship of Antonio Masiero, vicepresident of INFN, is currently in the process of elaborating a roadmap "respecting the budgetary constraints", that will become APPEC policy after discussions in the APPEC General Assembly early 2015; so what I can say now is still tainted by the priorities of the previous APPEC roadmap, elaborated in 2011, although informed by the current process to which I participate.

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The first and foremost expectation in the next few years is the first detection of gravitational waves in the advanced Virgo and LIGO antennas, so our support to the gravitational observatories, should be unfailing. An increase of sensitivity by two orders of magnitude in dark matter searches, e.g. by the detector Xenon 1T, and an order of magnitude increase of sensitivity in what is called neutrino-less double beta decays for neutrinos mass studies is also expected in the next few years.

Then the next two years will see the start of construction of the Cherenkov Telescope Array (CTA) observatory of high energy photons, the completion of the first phase of the KM3Net high energy neutrino observatory and the start of the upgrade of the Auger observatory of ultra high energy cosmic rays. In parallel, the large surveys of dark energy on ground (LSST) and in space (EUCLID) are funded and in advanced stage of construction.

Furthermore, an importance tendency of the astroparticle infrastructures is towards internationalization, since their size starts exceeding national or regional possibilities.

In this respect, APPEC has organized this summer in Paris, an international meeting implicating the leaders of world-wide agencies and leading principal investigators to promote the global coordination concerning the large infrastructures necessary to study the remaining parameters of the neutrino. Agencies and researchers converged on a well marked path for the following years.

A second meeting to gauge the progress is currently organized in April at Fermilab, in Chicago. This is global coordination path is source of optimism in the community but is not exempt of course of potential hurdles. Last but not least, the APPEC agencies wish to increase their contributions to the current and future cosmology program beyond this of dark energy, since the recent results from the LHC to PLANCK show that this is an area where important results may be obtained, through missions in space or on ground.

Surprisingly, although the above program seems large and ambitious, it does not require large increases of the yearly budget spent on astroparticle physics and Cosmology in Europe today, provided that projects come in a well thought time-order and coordination among European agencies is increased.

### **How can APPEC influence national and Europe policies? Which are the tools it uses for defining recommendations to the national agencies?**

Given the program above, it is clear that we are heading towards major decisions in 2017-2018, after the results of the current generation of dark-matter and double-beta decay experiments, the findings of the current LHC run, the end of the first phase of KM3Net, US and Japanese decisions on the neutrino program. APPEC prepares for this milestone date, through discussions at the scientific advisory committee, preparing the future evaluation committees and follow-up groups, assessing

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the current budgets at the level of its constituent funding agencies, promoting European Horizon 2020 programs aiming to coordinate the European underground laboratories, the gravitational wave antennas, the theoretical institutions and the large data centers. It also participates in programs of coordination with other large infrastructures, e.g. of Astrophysics or Particle physics. Last but not least, as mentioned above, is very active in promoting the coordination with non-European agencies on global scale infrastructure issues.

But above all, the specificity of APPEC and in particular its APPEC general assembly is the fact that it gathers heads of agencies around Europe and observers from important international organizations as CERN, ESO and JINR making it a forum where the future coordination actions are discussed in extension and common endeavors emerge.

**Both at the national and European levels, the research in this field often requires the realization of huge infrastructures and the preparation of challenging and costly space missions. Is it worth it?**

Well, I always say that worth and value have a temporality. They have, that is, their own clock. And the temporality, of fundamental science is different from this of the other human activities. I often remark that for instance in the previous economic crisis around the 1930's while economy and politics was plunging, science was producing its best: from quantum mechanics and general relativity to astrophysics and cosmology, through experimental and theoretical discoveries that still shape the present world. I further believe that today we live in a similar period, economic crisis accompanied with many future-shaping fundamental discoveries.

This difference in temporality has many aspects. First any scientific activity reduced to the engineering level, without advanced research immediately declines. You can see for instance the great importance that upcoming world powers as e.g. China put on fundamental research. Second, and if one accepts the first premise, one has to take into account the fact that results of fundamental importance do not come everyday and that often many people have to spend entire lives on a subject till they obtain a significant result. Third, often solutions to problems of society do not come if one simply puts everyone available to think on the same problem, but often come in unexpected ways through synergies or transfer from activities for fundamental science.

In this last case the specificity of astroparticle physics research is that it uses the Geosphere as both target and detecting medium. In order to satisfy its fundamental physics goals, it needs to collect continuous time series data, deploying large often autonomous sensor networks in hostile environments (sea, desert, underground), pioneering thus what is called today the "internet of objects".

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These characteristics of astroparticle physics infrastructures build a natural synergy between astroparticle physics and the geosciences, atmospheric and climate studies, biodiversity and many industrial applications. APPEC has made a few years ago, a preliminary list of these applications, in a brochure called “From the Geosphere to the Cosmos”, that one can find in the APPEC website. You would be surprised by the magnitude and wealth of the interdisciplinary applications that are born or could develop in the future from astroparticle research infrastructures or space challenging investigations.

*\*APPEC includes 15 funding agencies, governmental institutions and institutes from 13 European countries. Created in 2012, it emanated from the astroparticle physics European Coordination committee founded in 2001 as an outcome of a decade of preparatory work by a consortium of representatives and of the intense preparatory work provided by the EU-funded ERANETs ASPERA and ASPERA-2 (2006-2012). This work paved the way to the present APPEC consortium through a series of funding mechanism studies, common roadmap elaborations, common calls for R&D proposals and common outreach and communication activities.*