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Final Remarks

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This year we have to celebrate the 50^{th} anniversary of the book *"The structure of the scientific revolutions"* by Thomas Kuhn that has been published in 1963.. In this book, the more influential science philosopher of the last century, changed the old view of the development of the natural sciences as a linear process accumulation of knowledge into a substantially discontinuous passage from one paradigm to a new one.

Two drastic changes of paradigm occurred near the beginning of last centuries with the shift from Newton's absolute time to relativistic space-time and from Laplace determinism to quantum mechanics. Around the middle of the same century another crucial shift of paradigm was the introduction of Gauge Symmetries**,** that led to the formulation of the Standard Model of Electromagnetic, Weak and Strong interactions (SM for brief) [1], whose complete experimental verification has been given recently by LHC [2, 3]. The carriers of those three forces are spin-1 particles, namely the photon for the electromagnetic, the gluon for the strong and the $W^{\pm}$,Z for the weak one. It is well known that the first two particles are massless, while the others, that were discovered at LEP. have large masses ($\sim 80-90$ times the mass of the proton), which can explain the weakness of the corresponding interactions. Since the SM does not include gravity, there is no hint in it for the mass of the particles, that are put "by hand" in the Lagrangian. What is now usually called the "Higgs mechanism" [4, 5] is the possibility that the mass of particles, in particular that of the weak bosons, could be originated by the coupling with a universal scalar field, which carriers would be a weakly interacting spin-0 particles very similar to the one recently observed at LHC.

Nevertheless even a confirmed discovery of the Higgs would not be the end of the story, because thanks to Astronomy and Cosmology, we have strong observational evidences for phenomena like

- Inflation
- Dark Matter
- Dark Energy
- Baryon asymmetry

that are not understood in the framework of the minimal SM. This justify the diffuse opinion (hope?) that a lot of new physics remains to be discovered in the sky and laboratory.

1 Cosmological parameters

The results presented by Rubiño-Martin [6] on behalf of the Planck collaboration is one of the highlights of this conference. The new measurement of the Hubble constant from the fit of the CMBR obtained from the Planck satellite 2013 data is $H_0 = (67.3 \pm 1.2)$ km s^{-1} Mpc^{-1} is fully compatible with the previous value of 70 ± 2.2 published by WMAP collaboration. However the central value of H_0 is changed by non-negligible factor (-4%) that indicates that the age of the Universe is effectively $t_0 = (13.82 \pm 0.12)$ Gy, about 100 million longer then the previous estimate from WMAP. Incidentally that caused a funny "communication" problem with the media, because it was public ally announced on being the *"Universe older then the Big Bang"*.

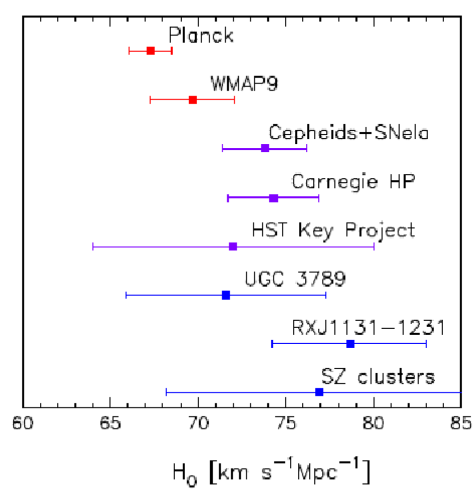

Figure 1: Reproduced from Ref. [6]

The tension of the H_0 value between HST key project (Cepheid+SNe Ia) and the CMBR anisotropy fit, shown in fig. 1, that was marginal (-1.2σ) with

WMAP, is now at a level of -2.5σ with the new Planck data. Not a suspicious level yet, but close to become interesting.

Table 1: Universe composition from CMBR

	Before Planck	After Planck
Dark Energy	72.8%	68.3%(-4.5% $\Downarrow$)
Dark Matter	22.7%	26.8%($+4.1\%$ $\Uparrow$)
Ordinary Matter	4.5%	4.9%($+0.4\%$ $\simeq$)
Total	100%	100%

A similar situation is observed in the determination of the ΛCDM composition breakdown as shown in table 1. The uncertainty on the fractions is estimated by the Planck collaboration to be about $\pm 3\%$ [7]. But it should be also stressed that this fraction are obtained with a multivariate fit over a constrained domain, in which correlations play an essential role. Therefore the fit error given independently for each of the variables could be strongly underestimated. Generally speaking a reliable error on the determination of each parameter should be obtained using the full covariance matrix of the fit, if definite positive.

2 Dark Energy

Nino Panagia [8], presenting the most recent results of the Hubble Supernovae Cosmology Project (SCP), strongly stressed that the ΛCDM model with $\Omega_\Lambda = 0.729 \pm 0.014$ indicating a present Universe dominated by the mysterious dark energy, are all based on the assumption that the explosive properties of the SNe Ia do not depend from redshift, up to $z \simeq 1.4$. Both the SCP and ground based telescope surveys of light curves and spectroscopic distributions of hundreds of supernovae, consistently found that the supernovae around $z \approx 0.5$ appear to be ≈ 0.3 mag dimmer then expected from a flat Universe with $\Omega_\Lambda = 0$. What if a cosmical conspiracy made the SNe at redshift ≈ 0.5 intrinsically dimmer? As predictable this pebble thrown in the placid pool (near Stockholm) started a heated discussion. Many in the audience supported the argument that the good fit of distance modulus vs. redshift curve [9] and of the TT spectrum of CMB fluctuations. In the discussion following the presentation of his paper, Nino questioned from a philosophical point of view that a successful fit is not to be taken as a definitive proof of validity for a theory. His point is absolutely correct, but Popper would object that a scientific theory can be falsified, not affirmed. Therefore we can exclude theories that do not fit the data, but not *viceversa*. On the same ground I think that would be very hard to fit the Planck data with $\Omega_\Lambda = 0$.

Harmes [10] has presented an interesting paper on a possible identification of the dark energy with solitonic primordial gravitational waves in the framework of Quantum Gravity with one warped extradimension, similar to the Russel Saunders one. Beside the specific model presented in that talk, that may explain both strength and time evolution observed by Planck [11], it has been speculated that dark energy could be the present manifestation of long lasting relics, with lifetime much larger then the Hubble time, produced in the Planck era ($t_U \lesssim 5 \times 10^{-44}$ s) by quantum gravity effects.

3 Dark Matter

Astrophysical evidence for dark matter is now overwhelming. In a recent paper Bahcall and Kuilier [12] tracing the mass-to-light ratio with dynamical and lensing methods, show that this ratio $M/L \gg 1$ is nearly constant for scales from $350h^{-1}$ kpc up to $22h^{-1}$ Mpc, while the fraction of the stellar mass over the total mass remains of the order of few percent over all scales and environments. It worth noticing that quantitatively the observed mass-to-light ratio on large scales gives an estimate of the mass density of the universe $\Omega_m = 0.26 \pm 0.02$, slightly smaller ($\approx 1.5\sigma$) then the Planck value [6].

After the discovery of the Higgs particle, dark matter is considered to be the most compelling evidence for new physics [13, 14]. Particle theory offers several type of objects that could play the role of observed dark matter, as for example axions and Majorana neutrinos, but excellent theoretical candidates are the supersymmetric neutral partners of the SM particles. LHC has definitively the possibility of discovering these particles if their mass is in the TeV range. However, as I said in my talk, there is a fruitful confrontation among astronomical observatories and accelerators but not a competition, because astronomy cannot demonstrate that WIMP's are supersymmetrical particles and accelerators cannot prove that a certain kind of particle really is the dark matter.

Several talks have described the status of the search for WIMP annihilation signal in γ-rays survey. In particular Morselli [15] presented on behalf of the Fermi-LAT collaboration several interesting results both on the diffuse component and of the GC region. At present we have some indications that the allowed mass scale for WIMP as well as the one of the SUSY neutralino at accelerators is to be found above several hundreds of GeVs.

4 UHE Neutrinos (?)

The detection of neutral particles in the km^3 detector IceCube [16] in Antarctica with an energy release ≥ 50

TeV is something waited since a long time. The study of a Deep Underwater Muon And Neutrino Detector (DUMAND) in the Pacific Ocean, off the shore of the island of Hawaii, USA, started in the late '70s [17]. But unfortunately after many years of R&D the project was interrupted in 1996, after the decision of the DOE Science Committee of not funding its deployment. In the meanwhile many other projects were initiated in many parts of the world, and often the collaborations have presented progress reports to the Vulcano conferences.

The IceCube collaboration has announced last April the detection of two contained showers with an energy estimated from the total number of photo-electrons $\gtrsim 1$ PeV. It is worth noticing that this energy estimate is based upon the assumption that all the light is emitted in the electromagnetic cascade. The total number of events (28) detected until now by the detector [18] seems to give the first clear indication of non-geophysical and extra-solar origin neutrinos.

1. Fargion[19] has proposed in his talk some intriguing possible mechanism originating these events, that could be tested in the future, when a larger number of events will be hopefully detected.

It is however to be stressed that these events are really exceptional under many aspects. If they are true neutrinos the c.m.s energy of their interaction:

$$\sqrt{s} = \sqrt{2m_N E_\nu} = 316 - 1400 \text{ GeV} \gg M_Z$$

is order of magnitudes larger than any neutrino-nucleon interaction observed in laboratory until now. It has been proposed in the past [20, 21, 22] that different kind of new physics could enhance substantially in this energy range. Moreover the detected showers could have been originated not by neutrinos but by new physics messenger, such as for example SUSY particles.

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- and finally Franco ... everybody knows why!

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Hope to meet You all at the Next Frascati Workshop