Concluding Remarks

Giulio Auriemma

Vulcano Workshop 2008

My personal choice
(Strictly subjective)

- Quantum Gravity via Lorentz Invariance violations
- Experimental determination of nuclear cross sections, relevant for solar neutrino emission and BBN
- Neutrino masses
- Quarks stars

$\Longrightarrow$With some final notes

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Quantum Gravity

L. Maccione

- Astroparticle physics is a very interesting testing ground for theories involving Lorentz Invariance Violations
  - Cosmological distances
  - Ultra High Energies
- Stringent limits to tiny effects suppressed by Planck Mass scale 1.2×10^{19} GeV
  - Emission spectrum in HE sources as the Crab nebula
  - Propagation of photons from GRB's at cosmological distances (birifrangence)
  - GZK effect (confirmed by Auger)
- Complementarity with accelerator searches for CPT violations and SUSY

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Exp. Determination of cross sections

C. Gustavino LUNA2 experiment at the LNGS

- Even if the overall phenomenology of solar neutrinos after SNO is completely internally consistent with the neutrino oscillation hypothesis, the cross section of $^3He(^3He,2p)^4He$ and $^3He(^4He,\gamma)^7Be$ are important inputs for a reliable solar model.
- BB nucleosynthesis gave the first indication
  1. Only 3 "light" families (Yukawa couplings < 1) later confirmed by LEP;
  2. Universal baryon asymmetry $n_B/s \simeq 10^{-10}$
- LUNA2 measurements of $D(p,\gamma)^3He$ cross section allows a reduction of a factor 3 over the error on predicted D fraction
- BBN is now on very solid grounds, usefull to set limits on alternative scenarios and new physics beyond the SM

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Neutrino mass

F. Ferroni Double beta decay

- Neutrino mass is by itself a violation of the SM, because SM $\Longrightarrow m_\nu = 0$
- Neutrinoless Double beta decay measures $m_{\beta\beta}$, which is a combination of the 3 neutrino mass eigenstates, the mixing angles and the Majorana phase, but is sensitive to the absolute value of the masses, not only to mass differences squared.
- Cuoricino result is $t_{1/2} > 3 \times 10^{24}$ y (more than 10^{14} Hubble times) with the limit $m_{\beta\beta} < 0.2 - 0.68$ eV $\Longrightarrow$ compatible with the solar and atmospheric neutrino oscillations.

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Quark stars

S. K. Gosh

- The subject of quark stars has a long story (The "arabian phoenix" of HE astrophysics ?) started well before the 80's (see e.g. Pacini & Salpeter NCim B51(1967)221).
- Stable "strangelets","quark nuggets" or "nuclearites" formed in the cosmological QCD transitions, with mass $> 10^7 A$ have been searched extensively with various tecniques
  - Limit by MACRO in the LNGS from exposure of 270 m^2 of CR39 for 7.7 years set an upper limit to the flux

$$\Phi < 10^{-16}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}\mathrm{str}^{-1} = 0.039 \left(\frac{\Omega}{4\pi}\right)\left(\frac{A}{100\ m^2}\right)\ year^{-1}$$

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Some final notes

- The Standard Model of Particle Physics is extremely well tested under all aspects, exception made for the Higgs sector, that escaped detection untill now (Altarelli, Perugia 2008)
- Direct search excludes that it mass is below 114.4 GeV, but radiative corrections sensitive to $\log_{10} m_H$ points to a value of $\log_{10} m_H = 1.88 \pm 0.16$ (LHC can find it if $m_H \lesssim 1$ TeV)
- Many open problems point to new physics beyond the SM at a scale $\sim$ few TeV's
  - The hierarchy problem
  - Baryogenesis
  - Dark matter

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> "Unification of couplings seems to require another extension of the Standard Model, to include approximate 'supersymmetry'. One of the main goals of the forthcoming Large Hadron Collider will be to see whether this is correct — if it is, a whole new world of phenomena will open up, involving new heavy partners for all known particles."
>
> F. Wilczek