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Closing Remarks:

Some personal thoughts at the dawn of the LHC era

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Lessons from accelerator physics

- The SM of PP works extremely well: a great achievement of 20th-century physics
- Is this a confirmation of LQFT?
- QM + SR => LQFT as an effective low-E approximation (S. Weinberg).
- Is the validity of the SM just a confirmation of QM & SR?
- Yes, modulo a crucial new point:the effective LQFT is a gauge theory!

Lessons from gravity and cosmology

- GR works very well on scales at which it has been tested
- GR, perhaps with a small cosmological constant, is the effective classical theory of gravity
- GR appears to be badly behaved at short scales (singularity theorems). Is QM the cure to those problems?
- QM appears to make things worse (UV divergences, induced cosmological constant, ...)!

The mystery of quantum corrections

- Radiative corections to marginal and irrelevant perators in the SM have been seen in precision experiments (e.g. LEP)
  - running of gauge couplings
  - effective 4-fermi interactions
  - anomalies
- Radiative corrections to relevant operators have not been seen (w/ exception of Newton's constant?):
  - scalar masses
  - cosmological constant
- Because of a (well-known?) IR-UV connection this may tell us something. The SM and GR are not the full story: they need an ultraviolet completion!

Why GT and GR?

- GTs are the only consistent way to deal with massless J=1 particles in a quantum-relativistic theory
- GR is the only consistent way to deal with massless J=2 particles in a Lorentz invariant way
- The question then becomes: Why does Nature like massless J=1, 2 particles?
- The answer could very well be: because She likes String Theory!

Does Quantum Gravity need a cutoff?

- Some people have still some hope to cure the deseases of QGR. I will give some arguments towards the opposite conclusion...
- They are based on invoking a bound on Newton's constant in terms of the UV cutoff. Then G_N-->0 as we remove the cutoff
- Old model-dependent arguments (GV, Dvali & Gabadaze, '02)
- More recently model-independent arguments (Dvali et al.,...., Dvali & GV to appear?)

A robust bound (?) .....

Let us make two assumptions in QG
w/ UV cutoff = $\Lambda_{UV} = 1/\lambda_{UV}$

1. A BH of radius R > λ_{UV} can be treated semiclassically using the standard formulae, for S, T, ev. rate etc

2. At least one of the following inequalities is satisfied by a semiclassical evaporating BH (c=1):

$$-\frac{d(2GM)}{dt} \leq 1 \quad ; \quad \frac{\hbar}{T^2}\frac{dT}{dt} \leq 1 \quad ; \quad \frac{\Gamma}{M} \leq 1$$

Then: $$\lambda_{UV}^{D-2} \geq N_{eff}(\Lambda_{UV}) l_P^{D-2}$$

Proof: If opposite true, take a BH of radius between λ_{UV} and $N^{\gamma} l_P$ ...

...and its implications

If one accepts above argument there two important consequences

1. A lower bound on M_P/Λ_{UV} implying that QG becomes trivial if cutoff is sent to infinity
2. The infinite bare coupling (Sakharov) limit of QG is non-singular

Too good to be true?

Farewell