La Búsqueda del Tiempo Perdido

Charlas Vocacionales para Pregrado 2009
PUC, 26 de Agosto 2009

Qué es, pues, el tiempo?
Si nadie me lo pregunta, lo sé; pero si quiero explicárselo al que me lo pregunta, no lo sé.
SAN AGUSTIN, Confesiones

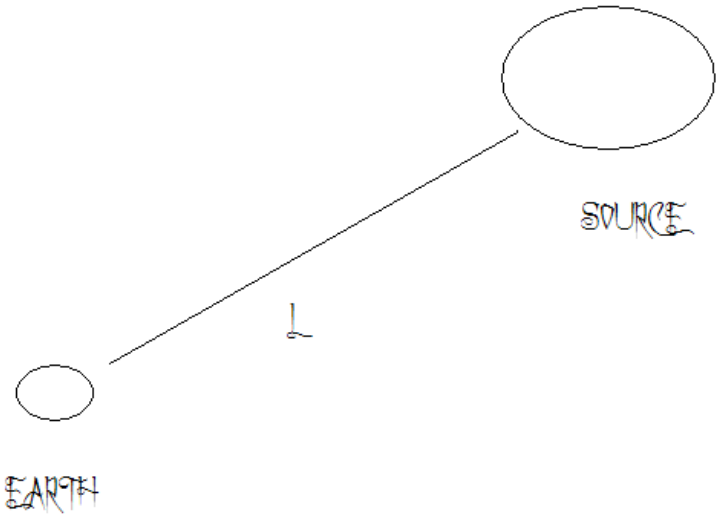
"You consider that to be important?" he asked.
"Exceedingly so"
"Is there any point to which you would wish to draw my attention?"
"To the curious incident of the dog in the night-time"
"The dog did nothing in the night-time"
"That was the curious incident", remarqued Sherlock Holmes.
Sir Arthur Conan Doyle, Silver Blaze

- Fenomenología de Gravitación Cuántica
- Cosmología y Física de Partículas
- Teoría de Gravitación Cuántica Renormalizable(Semiclassical Quantum Gravity)

Fenomenología de Gravitación Cuántica

Gamma Ray Bursts

G. Amelino-Camelia et al., Nature 393(1998)763.



$L \sim 10^{10}$ Light-years

PROPOSITION:

$$\delta v \sim \frac{E}{E_{QG}}$$

produces the structure of GRB with $\Delta t \leq 10^{-3}$ s.

$E_{QG} \sim E_{Planck} = 10^{19}$ Gev.

Dispersion Relation due to Quantum Gravity corrections(Strings, Loop Quantum Gravity, Effective Theories)

J.A., H. Morales-Técotl and L.F. Urrutia, Phys. Rev. Lett. 84(2000)2318.
JA, Phys. Rev.Lett. 94,221302(2005)

Ultra High Energy Cosmic Rays

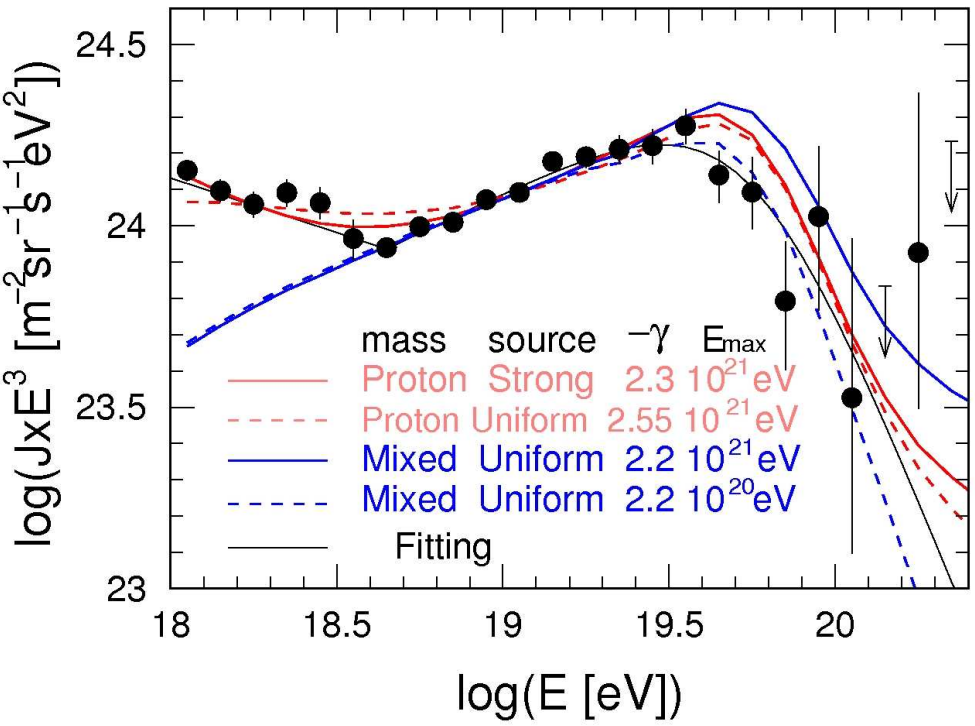
In this part of the talk we are concerned with the observation of ultra high energy cosmic rays (UHECR), i.e. those cosmic rays with energies greater than $\sim 4 \times 10^{18}$ eV.

- Although not completely clear, it has been suggested that these high energy particles are possibly heavy nuclei (we will assume here that they are protons).
- By virtue of the isotropic distribution with which they arrive to us, they originate in extragalactic sources.

The Greisen-Zatsepin-Kuz'min (GZK) cutoff

-Their propagation in open space is affected by the cosmic microwave background radiation (CMBR), producing a friction on UHECR making them release energy in the form of secondary particles and affecting their possibility to reach great distances.
- Cosmic rays with energies above 1×10^{20} eV should not travel more than ~ 100 Mpc.

The Auger Observatory has recently reported his observations on the highest energy cosmic rays.
They see the GZK cutoff in the flux. But still some of the cosmic rays have a trans GZK energy. This means that Lorentz invariance violation may be necessary to explain their presence, if nearby sources of such cosmic rays are not found.



The combined energy spectrum multiplied by E^3, and the predictions of three astrophysical models. The input assumptions of the models (mass composition at the sources, the source distribution, spectral index and exponential cutoff energy per charge at the acceleration site) are indicated in the figure.

Cosmología y Física de Partículas

Quantum gravity issues

-Cosmic Inflation

During a brief period of time, the size of the universe growth exponentially.

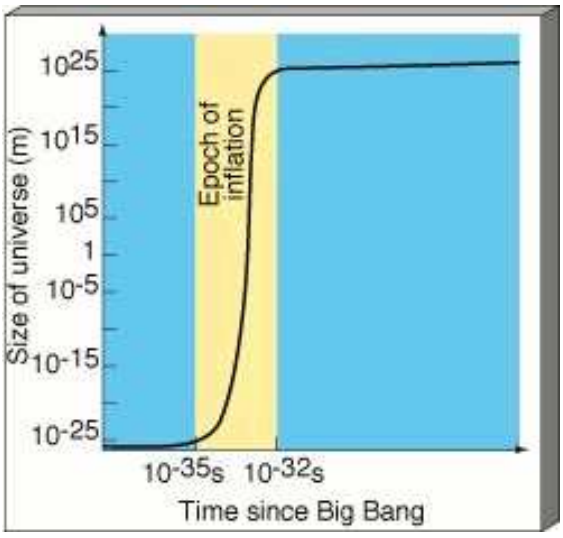


Figure 1.

Inflation predicts that the Universe is flat. WMAP satellite data on the CBMR support it.

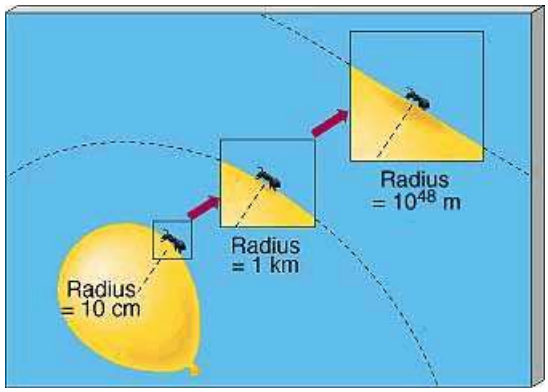


Figure 2.

QUANTUM GRAVITY?

- Gravity can be neglected compared to electroweak or strong forces among elementary particles, BUT at an energy of $M_P \sim 10^{19}$Gev becomes the dominant interaction.Proton mass $\sim$ 1Gev.

-The Universe at times $t < 10^{-35}$s after Big Bang, had an energy per particle $\sim M_P$.

-Gravity determines the initial conditions for the evolution of the Universe.

-At those early times, the Universe has atomic size, so Quantum Mechanics must be used to describe it.

- General Relativity is not RENORMALIZABLE

$$S = \int d^d x \sqrt{-g} (\frac{1}{2\kappa} R + \mathcal{L}_M)$$

Here $\kappa = \frac{8\pi G}{c^4}$ has dimension of M^{-2} rendering the perturbative series non-renormalizable.

-Two roads to Quantum Gravity:

i) String Theory. Basic objects are not point particles but one dimensional structures(strings). The theory is finite, has a pletora of vacua. Unify all forces d=10,26.

ii) Loop Quantum Gravity. Predicts space is discrete, black hole entropy follows from the Quantum Geometry. Continuum limit difficult.

Semiclassical Quantum Gravity

- Relatividad General sin materia es renormalizable a 1-loop.
- Relatividad General supersimétrica es renormalizable a 1-loop con materia.
- Con mi alumno Pedro Labraña inventamos las Teorías de gauge Semiclásicas, que justamente viven sólo a 1-loop. J.A. and P. Labraña, Phys.Rev.D65:045002,2002.
- Con mis alumnos de doctorado Pablo González, Ricardo Avila, Nicolás Zalaquett y Ernesto Frodden estamos explorando Semiclassical Quantum Gravity.
- Con mi alumno de magister Simón Riquelme estudiamos Campos Bosónicos como fuentes de torsión en gravitación.

Prácticas Recientes

Los informes de práctica completos están en http://www.fis.puc.cl/jalfaro/

- Nicolás Zalaquett, Anomalía del Pioneer 10/11(2006)
- Pablo González, Relación de dispersión no covariante y sus efectos en Cosmología(2007)
- Maximiliano Binder, Mecánica Cuántica Semiclásica(2009)

Gracias!