International Symposium

60 YEARS OF SUBNUCLEAR PHYSICS IN BOLOGNA

THE FUTURE OF OUR SCIENCE FROM THE EVOLUTION OF THE ELECTRON TO THE EVOLUTION OF THE UNIVERSE

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Accademia delle Scienze dell'Istituto di Bologna – Sala Ulisse
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PREAMBLE ON

THE EVOLUTION OF THE UNIVERSE

ANTONINO ZICHICHI

From 1897→ to →2018

The Dirac Equation,
describes the evolution of the
first elementary particle
(the smallest piece of electricity)
discovered
by J.J. Thomson in 1897.

This object, the great Thomson thought it was like a "ball".

No.

It was spinning.

Why?

Nobody knew.

More than 30 years were need, and the great Dirac, to find how to describe the evolution of the first elementary particle (**1928**).

In 1964 Dick Feynman

told me that the next step had to be to describe the evolution of the most complex object we know: our Universe.
You are the youngest fellow and should do it.

This is why I have encouraged great fellows of the International School of Astrophysics, such as

John Archibald Wheeler,

Peter Bergmann

and Nathan Rosen

to think about the

Evolution of the Universe.

Purpose of this lecture is
to encourage all of you
to devote some time
on this problem.

The first step in the Evolution of the Universe must be to explain the values for the mass and the vacuum of our Universe.

The second step has to be related to the GAP between the Gravitational Force and the other Forces [QED, QFD, QCD]

QED ⇒ All Electromagnetic Phenomena (Quantum ElectroDynamics)

QFD ⇒ All Phenomena generated by the Weak Forces (Quantum FlavourDynamics)

QCD ⇒ All Phenomena generated by quarks, gluons with their strong subnuclear "colour" charge

THE FIRST STEP

The Mass and the Vacuum of our Universe

We would like to understand the origin of the mass and of the vacua of our Universe on the basis of the Planck fundamental constants and the Schwarzschild solution of the Einstein equation.

The fact that the Schwarzschild equation [1] allows to get the value for the mass and the vacua of our Universe **when**, starting from the Planck Universe, its radius increases by 62 powers of ten, cannot be a casual coincidence, but the result coming from the Evolution of the Universe.

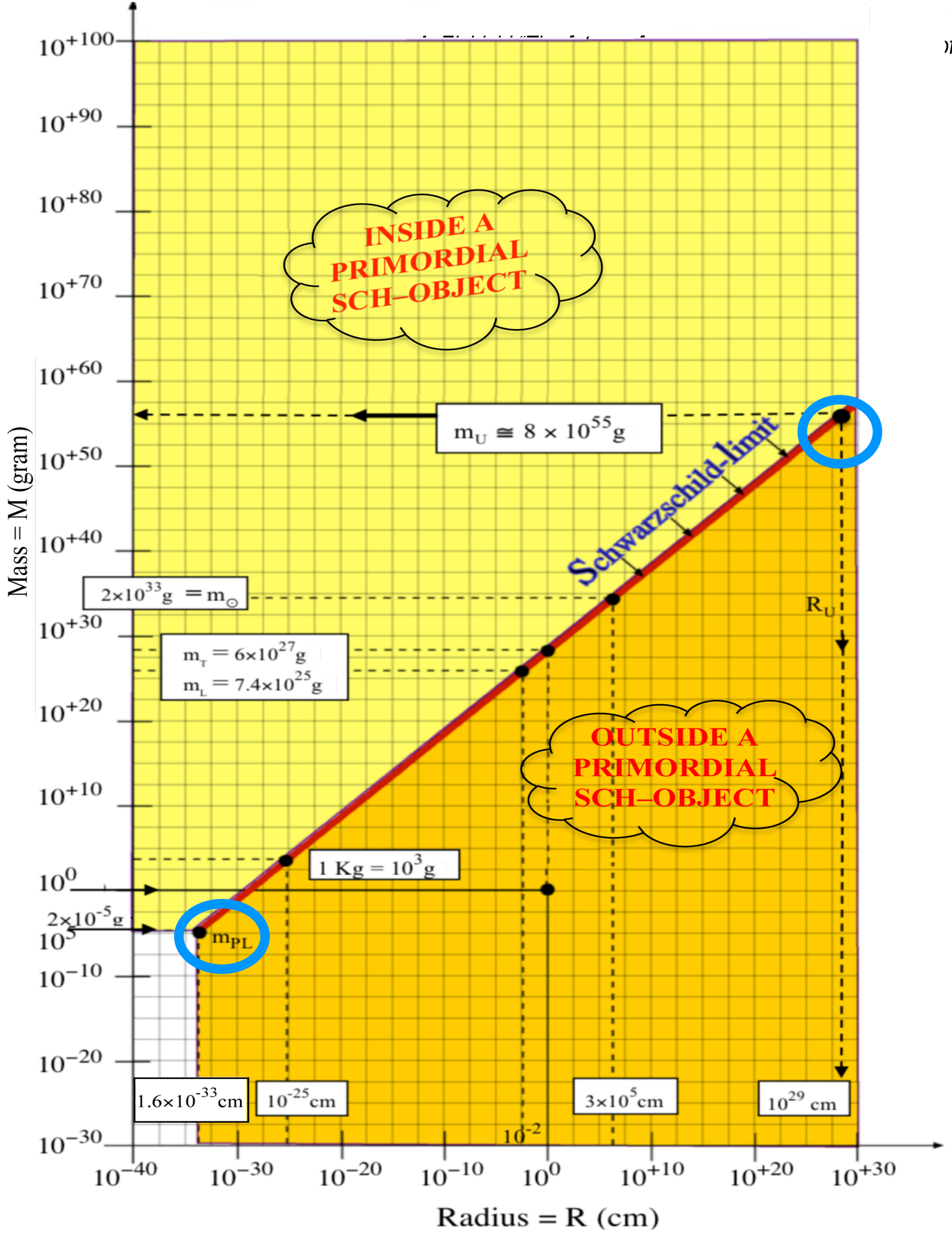
We know that the structure of our Universe has the Galaxies concentrated along lines and planes immersed in very large amount of empty spaces.

The first of these empty spaces
was discovered in 1981
in the Boöte constellation.
It is estimated that
about 98%
of the Universe volume
is empty.

The reason why these empty spaces must exist is the consequences of its evolution.

We find that the evolution is described by the Schwarzschild equation [1] which predicts that the density of the Universe must decrease with the square of its mass.

The evolution of the Universe
is illustrated in Figures 1 and 2
whose origin is
in the intellectual venture
whose author is Max Planck [2].



INSIDE A PRIMORDIAL SCH–OBJECT
OUTSIDE A PRIMORDIAL SCH–OBJECT
Schwarzschild-limit
$m_U \cong 8 \times 10^{55}$g
2×10^{33}g $= m_\odot$
$m_T = 6\times10^{27}$g
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1 Kg = 10^3g
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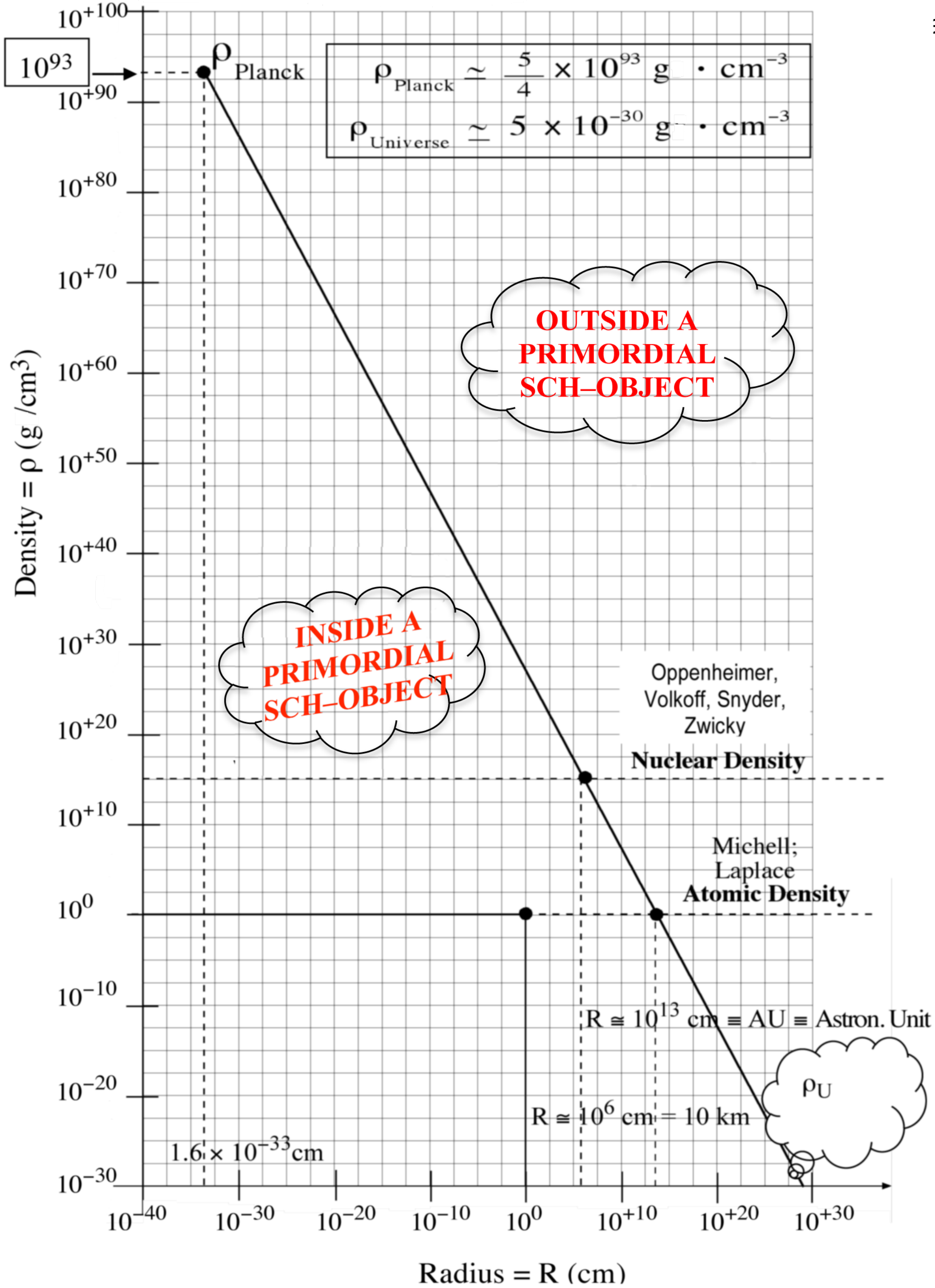
10^{-25}cm
10^{-2}
3×10^5cm
10^{29} cm
Mass = M (gram)
Radius = R (cm)

Figure 1

Figure 1: The Schwarzschild law between the radius of the horizon and the mass from the smallest to the largest SCH–object.



10^{93}
ρ_{Planck}
$\rho_{Planck} \simeq \frac{5}{4} \times 10^{93}$ g · cm^{-3}
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Oppenheimer, Volkoff, Snyder, Zwicky
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Figure 2

Figure 2: The relation which exists between the value of the SCH radius (R_{SCH}) and the corresponding density (ρ_{SCH}), from the smallest (the Planck Universe) to the largest SCH–object (the Universe now).

In his universal outlook of the world – independent of our restricted environment– Planck in 1899 wanted that the fundamental units of mass, length and time to depend only on the values of the fundamental constants of Nature:

c (the speed of light),
h (the Planck constant) and
G_N (the Newton gravitational coupling).

These quantities had a special meaning for Planck [2]:

"*These quantities retain their natural significance as long as the Law of Gravitation and that of the propagation of light in a vacuum and the two principles of thermodynamics remain valid; they therefore must be found always to be the same, when measured by the most widely differing intelligence according to the most widely differing methods*".

The way Planck considered these quantities it is remarkable:

"*In the new system of measurement each of the four preceding constants of Nature (G, h, c, k) has the value one*".

This is
the meaning of
measuring lengths,
times,
masses
and temperatures
in Planck's units.

Planck included the Boltzmann constant *k* which converts the units of energy into units of temperature. This allowed Planck to have a fundamental value also for the temperature, 3.5×10^{32} kelvins (K).

Here are the orders of magnitude of Planck's units in the "Planck Universe":

$$
\begin{array}{llll}
\text{Length} & = (G \cdot h/c^3)^{1/2} & \simeq & 10^{-33}\ \text{cm} \\
\text{Time} & = (G \cdot h/c^5)^{1/2} & \simeq & 10^{-44}\ \text{s} \\
\text{Mass} & = (h \cdot c/G)^{1/2} & \simeq & 10^{-5}\ \text{g} \\
\text{Temperature} & = k^{-1} \cdot (hc^5/G)^{1/2} & \simeq & 10^{32}\ \text{K.}
\end{array}
$$

When Planck was expressing his ideas on the meaning of his fundamental natural units there was neither the Big Bang nor the Einstein equation.

And no one knew that the Einstein equation had a solution, discovered by Karl Schwarzschild [1], which describes the gravitational field of a massive point-like particle.

John Wheeler in 1967 gave to this solution the name of "black hole", the reason being that even the light cannot escape the gravitational attraction.

This extremely successful name given to the Schwarzschild solution of the Einstein equation produced the effect of neglecting the fundamental meaning of the Schwarzschild formula which establishes between the radius of the gravitational horizon (R^{PM}) of a point-like massive (PM) object and its mass (M^{PM}) a very important coupling:

$$R^{PM} = \frac{2G\,M^{PM}}{c^2} \cong$$

$$\cong 1.5 \cdot 10^{-28} \cdot cm \cdot g^{-1} \cdot M^{PM} \qquad (1)$$

The radius
of the gravitational horizon
increases with the mass,
as shown in Figure 1.

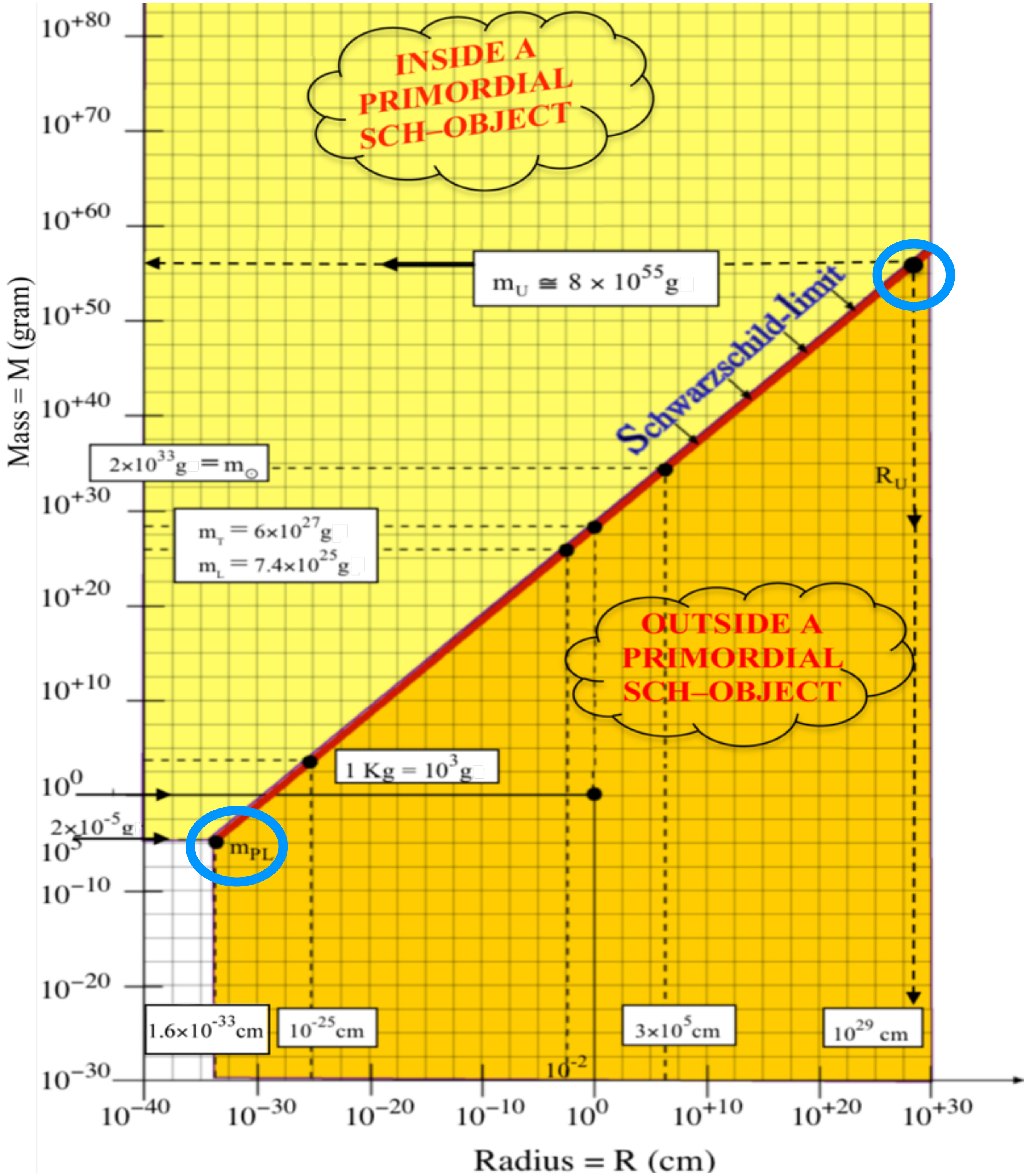
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Figure 1

The Schwarzschild formula remains as it is despite all developments [3, 4] in the physics of black holes including what has been discovered by RQST (Relativistic Quantum String Theory, see later).

The remarkable fact is however that if we look in Figure 1 at the point where the radius of the horizon is that of the world where we leave (about 10^{29} cm) the mass turns out to be $\simeq 10^{56}$ g , which is the mass of our Universe (without dark matter and dark energy, see later).

Let us now assume that M^{PM} is not concentrated in a point, as in the Schwarzschild solution of the Einstein equation, but distributed inside the volume defined by the sphere of the black hole gravitational horizon.

We assume that the black hole horizon [5] is the surface of a sphere where M^{PM} is distributed. We define as "primordial Schwarzschild object" (primordial SCH–object) the sphere whose mass is M^{PM}.

We neglect details
like
$[(4/3)\,\pi]$
in front of
R^{PM}
to have the volume.

Since the density is given by the mass over the volume

$$\rho_{PM} = \frac{M^{PM}}{V^{PM}} = \frac{M^{PM}}{(K \cdot M^{PM})^3} ,$$

the result –following the Schwarzschild equation (1)– is that the density decreases with the square of the mass

$$\boxed{\rho = K^{-3} \cdot M^{-2}} \quad (2)$$

with

$$K = \frac{2G}{c^2} \cong 1.5 \cdot 10^{-28} \text{ cm} \cdot \text{g}^{-1} .$$

In Figure 2 the density of our Universe,

$$\rho_{\text{Universe}}\,,$$

and the Planck density,

$$\rho_{\text{Planck}}\,,$$

are given as a function of the radius of all possible horizons produced by all possible masses allowed by the Schwarzschild solution of the Einstein equation.

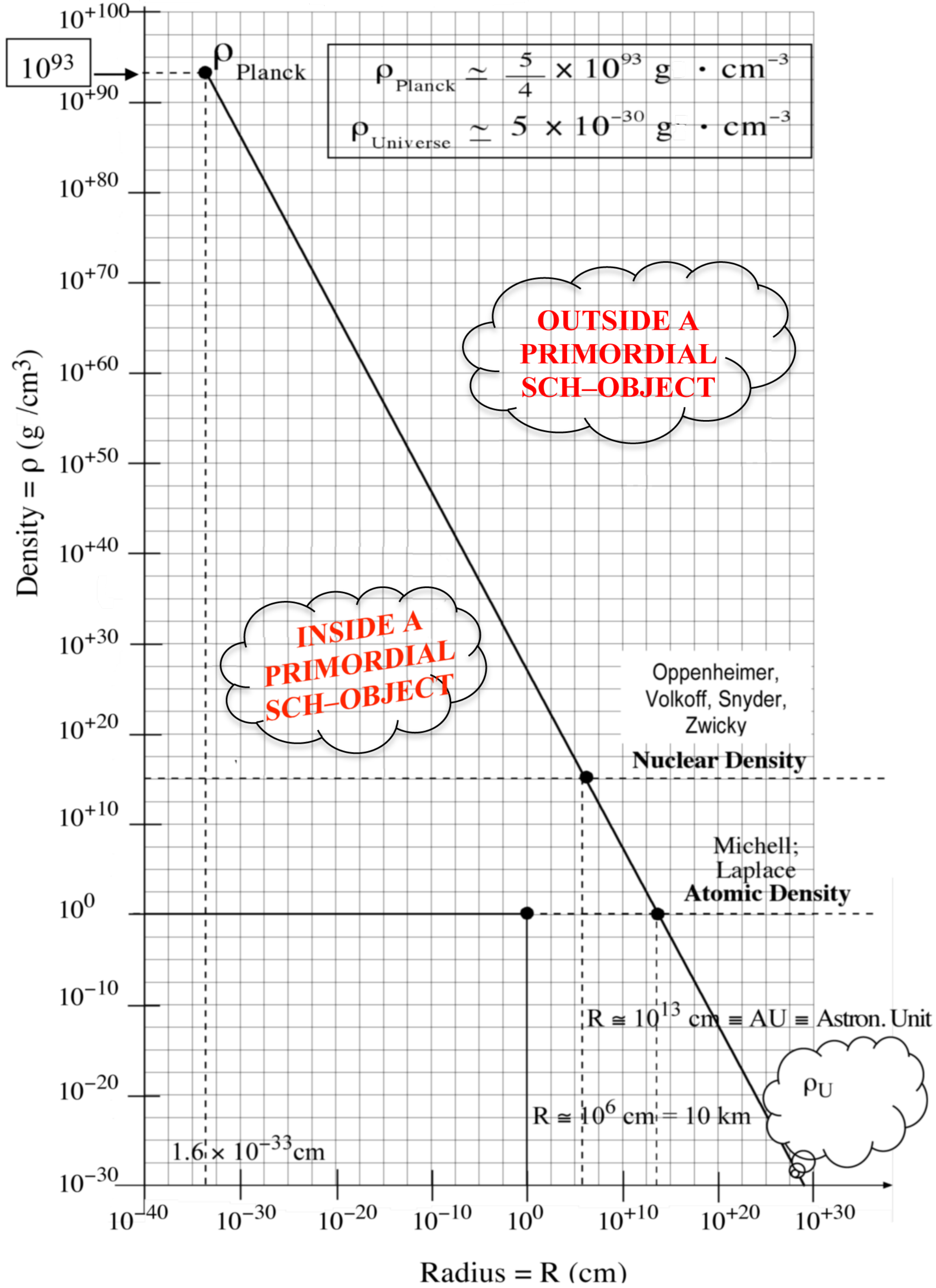

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Figure 2

It is interesting to see (Figure 2) the different values of densities which can go from the minimum,

$$\rho_{\text{Universe}} \,,$$

to the maximum,

$$\rho_{\text{Planck}} \,.$$

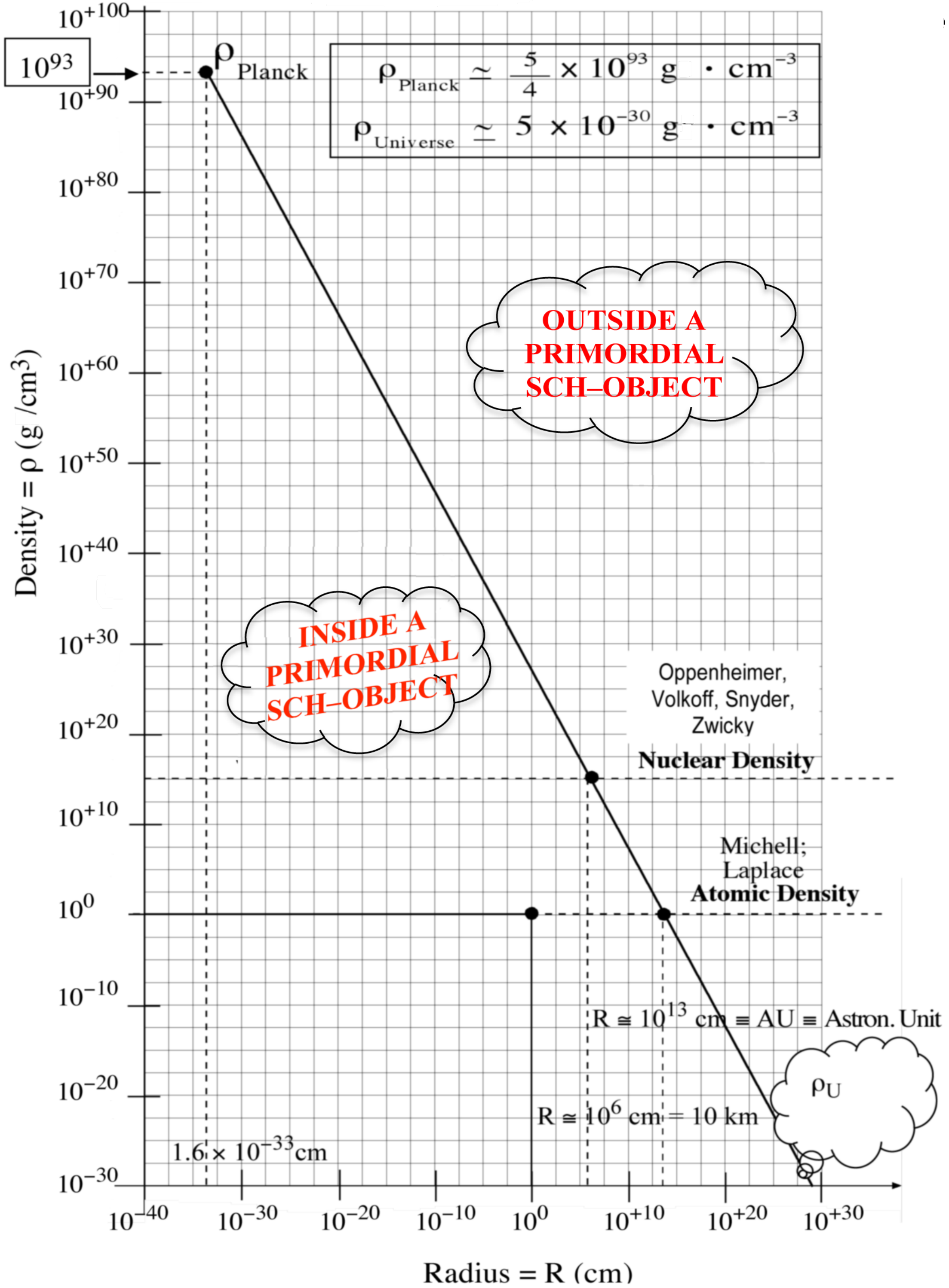

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Figure 2

The density which has attracted the interest of John Michell in 1783 and independently of Pierre-Simon de Laplace in 1796 is the "atomic" density.

It took more than a century for the "nuclear" density to come in the game and attract in 1939 the interest of Robert Oppenheimer, George Volkoff, Hartland Snyder and Fritz Zwicky.

For both forms of matter, atomic and nuclear, the density does not change when the amount of matter increases: one ton of lead has the same density as one kilogram of lead.

For matter where the binding force is gravitational (without any other forces being involved) –following the Schwarzschild equation– **the density decreases with the square of the mass** (2). This is the great novelty derivable from the Schwarzschild equation [1].

On many occasions, during the activities of the International School of Cosmology and Gravitation, in Erice, I have been discussing with friends and colleagues (including John Wheeler [6, 7], Nathan Rosen [8] and Peter Bergmann [9–17]) how it happens that no one has been able so far to derive the **mass** and the **vacua** of our Universe.

For example the number of protons, neutrons and electrons that our Universe is made of, which is about

$$\boxed{N_{(p\,n\,e)} \simeq 10^{80}\,.}$$

Despite the enormous work devoted to understand the physics of black holes [3, 4] including the study of Quantum Gravity [18] and the Relativistic Quantum String Theory (RQST) [19] with the interesting discovery of the "landscape" [20], no one has been able to get the easier goal, namely the Universe mass and vacuum.

The mass is about 10^{56} grams, if we ignore the problem of dark matter and dark energy.

The dark matter and dark energy will bring the mass to $\simeq 10^{58}$ grams but will not contribute to increase the number of $N_{(p\ n\ e)}$.

Our Universe has a number of galaxies of about $2 \cdot 10^{11}$; each galaxy has, on the average, a number of stars of about the same order of magnitude, $2 \cdot 10^{11}$.

The average mass of each star is in the range of the mass of our Sun

$$\simeq 2 \cdot 10^{33}\mathrm{g}.$$

The total mass
of the Universe
turns out
to be
about

$$\boxed{m^{\text{Universe}} \simeq 8 \cdot 10^{55}\,\text{g} \simeq 10^{56}\,\text{g}.}$$

$c \equiv$ *The velocity of light*

$h \equiv$ *Planck's Constant*

$G_N \equiv$ *Newton's Constant*

From this **Units** the following values come

10^{-33} cm

10^{-5} gr

10^{-44} sec

An interesting point is to know if the primordial SCH–objects are scale invariant: i.e. if the laws of Physics remain valid inside small and big primordial SCH–objects. We know that there are information problems in the black hole physics [21].

What we are sure of is that the law of Physics remains valid inside a primordial SCH–object, provided that this "object" is as large as our Universe. This finding could be related – applying the time-reversal invariant operator T [22, 23] – to the problem theoretically studied by Gerardus 't Hooft [24].

He says on p. 77: "*If the original amount of material was big enough, the contraction will proceed, and, in the limit of zero pressure and purely radial, spherically symmetric motion, the equations can easily be solved exactly. We obtain flat Space-Time inside, and a pure Schwarzschild metric outside. As the ball contracts, a moment will arrive when the Schwarzschild horizon appears. From that moment on, an outside observer will no-longer detect any radiation from the shell, but a black hole instead*".

The Universe where we have life and knowledge is an example of a very large primordial SCH–object.

Sooner or later the mass and the vacua of our Universe should come out from RQST.

Meanwhile their origin remains in the three fundamental constants of Planck and in the Schwarzschild solution of the Einstein equation if the point-like massive objects are replaced by the primordial SCH–objects.

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THE SECOND STEP

The GAP between the Gravitational Force and the other Forces [QED, QFD, QCD]

The energy level where the best values of the three fundamental gauge couplings (α_1, α_2, α_3) converge is at least two orders of magnitude below the Planck energy level. The existence of this Gap could imply that the gravitational force *'comes into being'* before QED, QFD and QCD.

x

The most interesting consequence of the Gap would then be the existence of matter whose charge is only the gravitational charge.

If this is so, events should be detected where only gravitational waves are produced.

Primordial black holes (PBHs) would be produced much more frequently than the standard black holes (SBHs) since SBHs would be '*derivative*' effects produced later, after matter made of protons, electrons, neutrons, and stars can exist.

Collisions between PBHs generating only gravitational waves would be more frequent than SBHs collisions.

THE GAP AND THE ORIGIN OF THE FUNDAMENTAL FORCES

We would like to call attention on the energy Gap which exists between the energy level E_{GUT}

[where the three gauge couplings
α_1 (QED),
α_2 (QFD) and
α_3 (QCD) converge
towards a common origin, α_{GUT}]

and the Planck energy level, E_{Planck}.

This Gap could be the first evidence for the origin of the fundamental forces to be at two different energy levels.

The first energy level being the one where the gravitational force "*comes into being*": in 1977 John Wheeler recalled [1] that we should care to study how

<u>*"the laws come into being"*</u>.

Since no one has been able to solve this problem, the solution has been given for granted: all fundamental forces start at the same instant with a Big Bang.

In this case the Gap should not exist, due to the fact that all forces start at the same energy level.

The existence of the Gap opens new problems on the study of the gravitational forces. For example the study of the spectrum of the primordial black holes (PBHs) produced before

QED, QFD and QCD

"come into being".

These PBHs possess only the gravitational charge. The first PBH is the smallest object in the Universe, with mass 10^{-5} g and radius 10^{-33} cm: the Planck PBH.

During the existence of the Gap
no other forces could be active.

Only gravitational waves and particles with gravitational charge exist.

The mass spectrum of the PBHs cannot be derived from fundamental principles but described by models [2].

Let us not forget that the masses of all particles of the Standard Model of Subnuclear Physics [3] are not predicted but experimentally measured. This is why we should be prepared to experimentally determine the masses of the PBHs, as already started to be done by the LIGO-VIRGO collaboration [4].

The existence of the Gap is illustrated in Figure 1.

The present value of E_{GUT} is based on the most exact study of the evolution with energy of the three gauge couplings (α_1, α_2, α_3) [5].

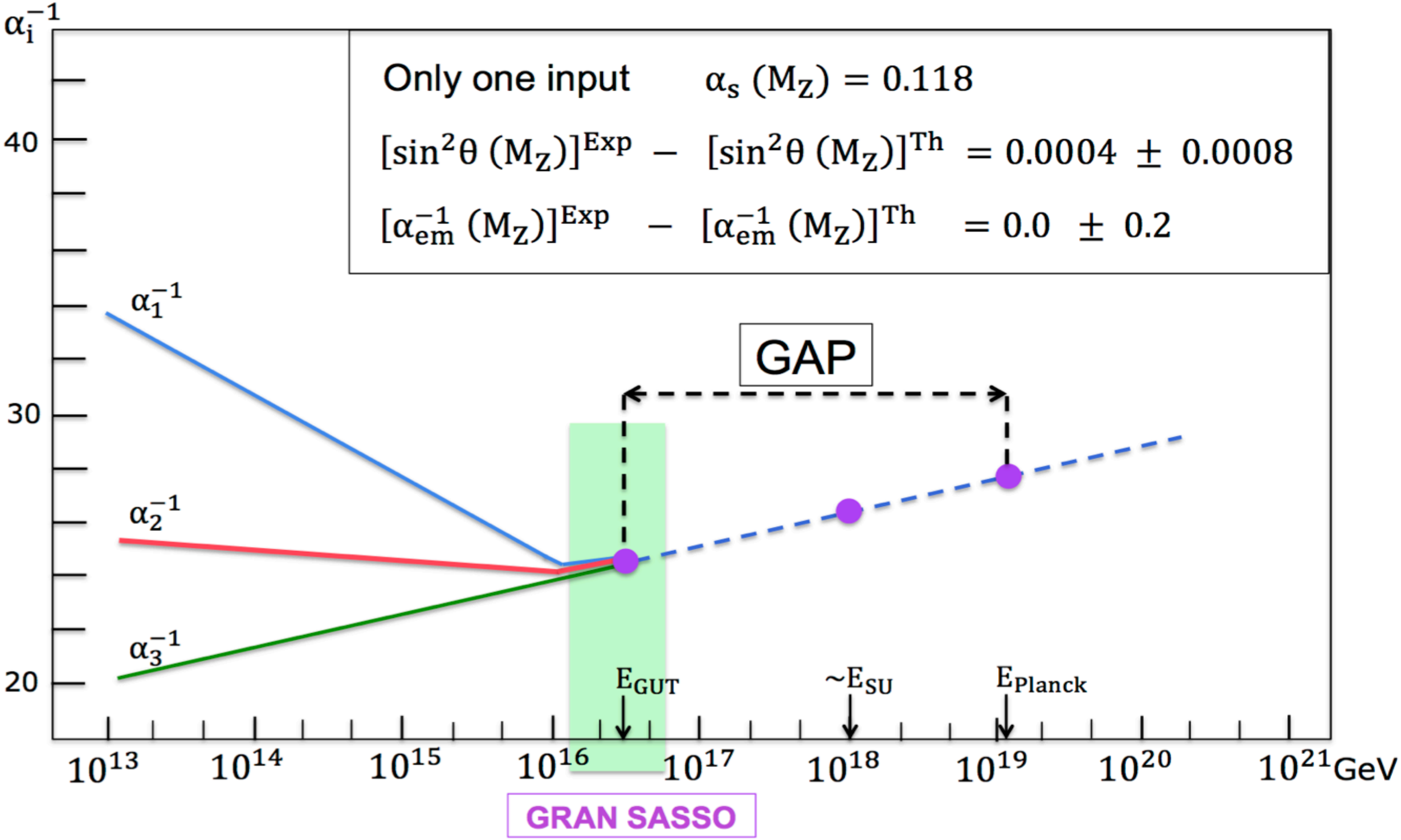


Figure 1: The Gaps between the Planck energy, E_{Planck}, and the two energy levels, E_{GUT}, where the three gauge couplings converge, and E_{SU}, where the RQST (Relativistic Quantum String Theory) [9] puts the origin of the gravitational forces [5]. The Gran Sasso label indicates the biggest underground laboratory to study neutrinos and cosmic energies of extremely high values.

It should not be forgotten that **during more than ten years** (from 1979 to 1992), no one realized that the energy threshold for the existence of the superworld (i.e. the threshold for supersymmetry breaking $E_{SUSY}^{(\neq)}$) was strongly dependent on the **running of the masses**.

Until 1992 it was so.

The **then best theoretical** prediction [6] for the energy threshold of the superworld,

$$E^{(\neq)}_{SUSY},$$

was calculated to be **21 TeV**.

The authors of this prediction computed, as everybody else, **the energy threshold**

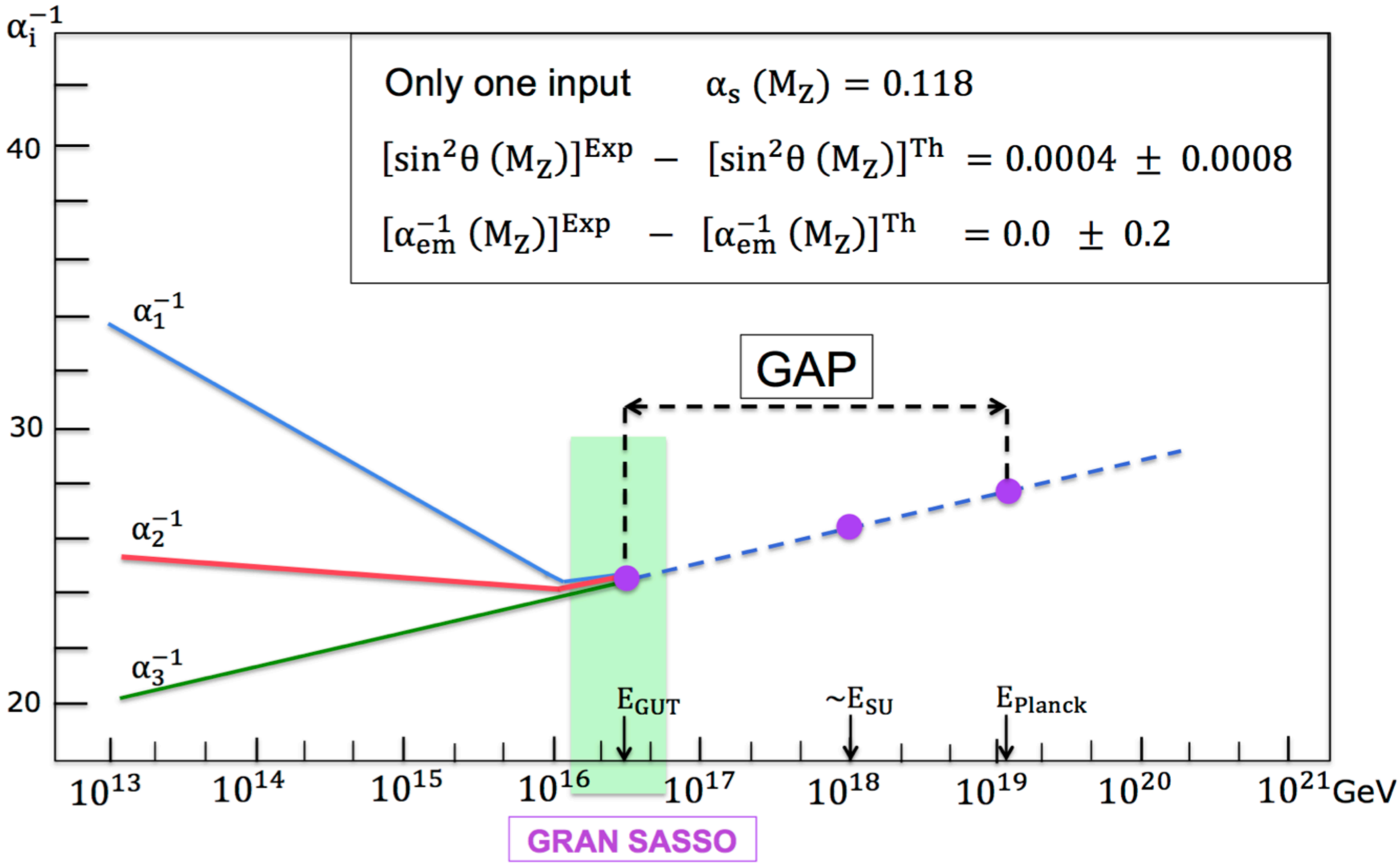
$$\mathbf{E}_{\mathbf{SUSY}}^{(\neq)}$$

using only the running of the gauge couplings

$$(\alpha_1, \alpha_2, \alpha_3)$$

which corresponds to **neglecting** [6] nearly **three orders** of magnitude in the energy threshold for the discovery of the lightest particle of the superworld (LPS), **as proved in Ref. 7**.

The running of the masses is now called the **EGM effect** (from the initials of **E**volution of **G**augino **M**asses). Since then many other measurements of the gauge couplings at higher energies have been obtained; the values of α_1, α_2, α_3 have been confirmed [8] and the Gap, reported in Figure 1, remains as it was in **1992** [5].



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The **consequences of the Gap** in understanding **the origin of our Universe and its evolution** is one of the most interesting problems in front of us.

The first question is how the Universe would be if only gravitational forces were active. There would be neither stars nor standard black holes (SBHs).

In this Universe **only gravitational waves could exist** and **masses with only one type of charge**: the **gravitational one**.

Between the two extreme levels,

E_{GUT} and E_{Planck},

there is the energy level E_{SU}, where the Relativistic Quantum String Theory (RQST) [9] puts the origin of the gravitational forces, i.e. **the string unification scale E_{SU}**.

Superstring theory **does not provide** the fundamental length. This is derived from the Planck length.

The string unification coupling, α_{SU}, where all gauge interactions join with gravity rather than being an arbitrary parameter, is determined by the vacuum expectation value (**VEV**) of a scalar field, the so-called **dilaton** $\phi(t)$ (for a review see Ref. 10).

Superstring theory **does not** provide the VEV of the dilaton. This is taken to be equal to α_{GUT} at the E_{GUT} scale.

Taking into account the RQST it is necessary to multiply

$$E_{\mathrm{Planck}} \text{ by } \sqrt{\alpha_{\mathrm{SU}}}\;.$$

The result goes down to

$$E_{\mathrm{SU}} \simeq 10^{18}\,\mathrm{GeV}.$$

and the energy interval of the Gap becomes

$$(10^{-16} \div 10^{-18})\ \mathrm{GeV}.$$

The conclusion is that E_{SU} is not a spectacular result of RQST.

It is very strongly related to E_{Planck}.

Few words on the study of the pre-Big Bang.

Gabriele Veneziano and collaborators [11] proposed the existence of a

stochastic background of gravitational waves.

These waves are coming from **the Universe which** existed long before the '*quantum of time*' in what they call a pre-Big Bang phase. The stochastic background has a characteristic frequency spectrum [12], several orders of magnitude **higher** than that of **standard inflationary cosmology**.

This '*gravitational light*' would be the effective radiation emitted at times of the order of the Planck time $(\simeq \mathbf{10^{-44}s})$.

Another interesting effect is the amplification of electromagnetic fluctuations, due to the drastic variation of α_{SU}, which could provide the long-sought explanation for the observed **galactic magnetic fields** [13].

All these ideas have
no effects
on the existence of the Gap.
The only effect
is the
production
of a background
of gravitational waves.

End of the few words on the PRE-BIG BANG

And **now back** at the time of the 1979 EPS Geneva Conference, when

"*the three gauge couplings,*

α_1, α_2, α_3,

were not converging in a point but in a sort of triangle" (Figure 2).

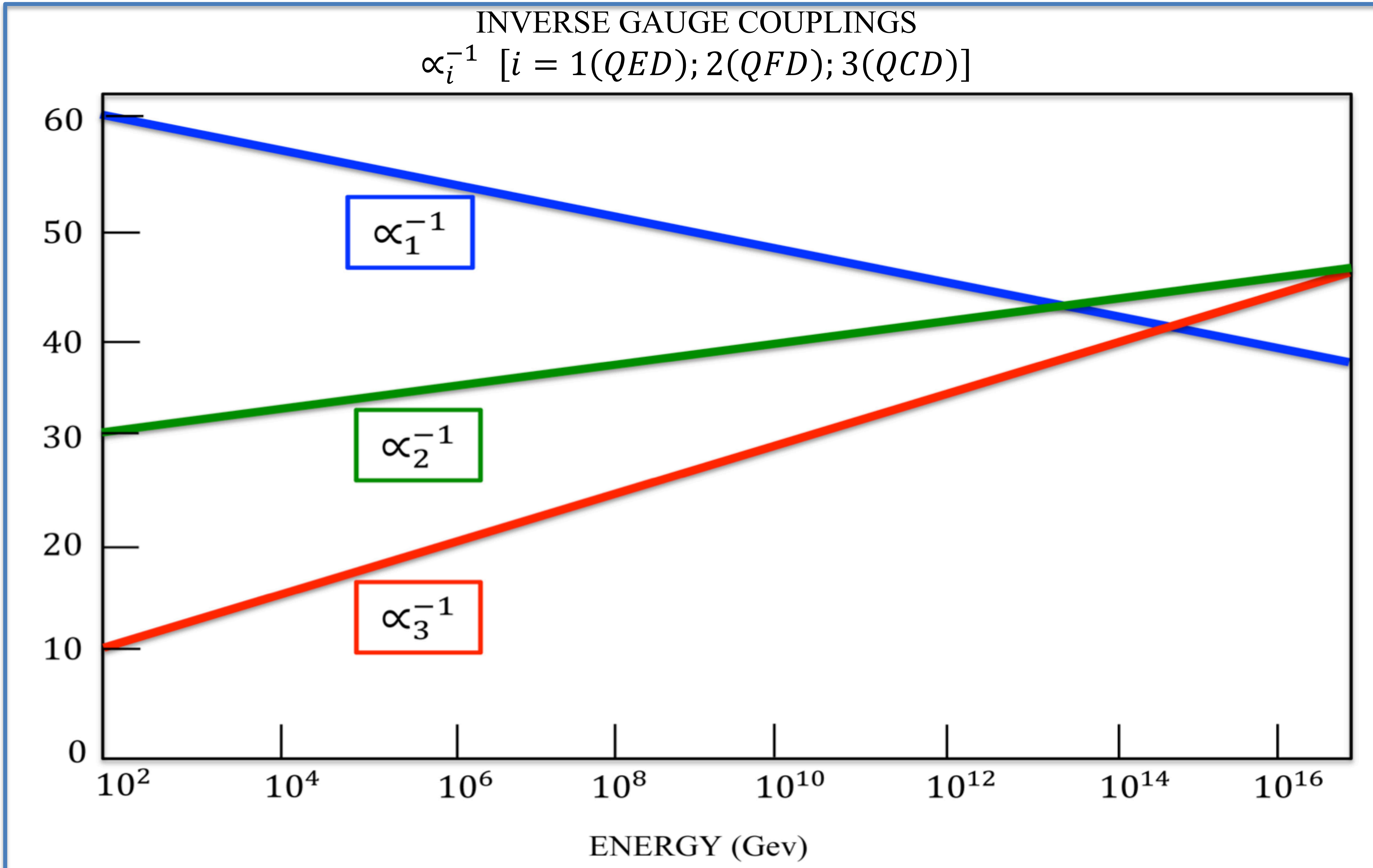
INVERSE GAUGE COUPLINGS
$\propto_i^{-1}$ $[i = 1(QED); 2(QFD); 3(QCD)]$
60
50
40
30
20
10
0
$\propto_1^{-1}$
$\propto_2^{-1}$
$\propto_3^{-1}$
10^2
10^4
10^6
10^8
10^{10}
10^{12}
10^{14}
10^{16}
ENERGY (Gev)

Figure 2

These words are of Rudolf Mössbauer [14]. The three gauge couplings

$$(\alpha_1, \alpha_2, \alpha_3)$$

do converge towards a unique value

$$\alpha_{\mathrm{GUT}} \simeq \frac{1}{25}$$

at the energy **$\alpha_{\mathrm{GUT}} \simeq 10^{16}$ GeV if the existence of supersymmetry** is introduced [15] in the evolution equations of

$$\alpha_1, \alpha_2, \alpha_3.$$

As mentioned before the energy evolution of the three couplings

$$\left.\begin{array}{l} \alpha_1\ (q^2) \\ \alpha_2\ (q^2) \\ \alpha_3\ (q^2) \end{array}\right] \qquad (1)$$

had never before been performed with the **new condition** [7, 16] based on the energy dependence, not only of the gauge couplings themselves, but also of the masses: i.e. the

EGM (Evolution of Gaugino Masses) effect [7, 16-18] mentioned before.

The EGM effect
produces nearly
three orders of magnitude
(a factor **$(700)^{-1}$**),
for the threshold of
supersymmetry breaking,

$$E_{SUSY}^{(\neq)}$$ [18].

Suppose the convergence of the three couplings (α_1, α_2, α_3) is computed taking into account the evolution of each coupling with q^2, neglecting the variation of the masses associated with the physics of the given gauge group, i.e. U(1) for α_1, SU(2) for α_2 and SU(3) for α_3.

Suppose the prediction is

$$E_{SUSY}^{(\neq)} = \mathbf{700\ TeV}.$$

Using the same model this prediction becomes **1 TeV**, if the EGM effect [7, 16-18] is included: the search for the lightest supersymmetric particle becomes possible at LHC.

The EGM effect is important for the lowest limit of the Gap, while the upper limit is given by the Planck energy level.

In the energy interval

$$(10^{16} \div 10^{18})\ \text{GeV}$$

the Universe consists only of what the gravitational forces can do in terms of ***'primary'*** **effects** [1], not ***'derivative'***.

The primary effects are the 'primordial Schwarzschild objects' **(P-SCH-objects)** previously discussed.

We have pointed out that our Universe seems to be the proof that a P-SCH-object, starting from the **Planck Universe**, can expand its radius by something like **62 orders** of magnitude following the conditions dictated by the Schwarzschild solution of the Einstein equation.

The Einstein equation and the Schwarzschild solution ignore the existence of $SU(3) \times SU(2) \times U(1)$. The convergence of the three gauge couplings (α_1, α_2, α_3) at E_{GUT} is nearly two orders of magnitude below E_{SU}.

In this energy Gap the P-SCH-objects are produced, which could indeed be the seeds of all galaxies.

If we could see the inner structure of these objects we would find that the matter they are of is not the one familiar to us, i.e. a matter made of protons, electrons and neutrons (p, e, n).

The **P-SCH-objects**, as said before, are made **of matter whose charge is only the gravitational charge**.

Their size is not necessarily confined within the **cosmological horizon**.

Inflationary scenarios allow for even larger PBHs, the so-called super horizon PBHs [20].

Standard black holes (SBHs) [21] are produced later, when QED, QFD and QCD are switched on.

SBHs are actually due to ***derivative* effects produced** by matter made of (p, e, n).

All we can do
is to study the collisions
of two black holes,
as done by Riccardo De Salvo,
Walter Del Pozzo
and Collaborators.
If they are P-SCH-objects [19], these
collisions would generate **only**
gravitational waves.

If these gravitational waves are not accompanied by electromagnetic waves and/or neutrinos, this would be evidence that **P-SCH-objects exist**.

These **P-SCH-objects** could solve the problem of the missing mass in the Universe, for the very simple reason that P-SCH-objects are directly produced at extremely high energy when only the gravitational forces are active [19].

Their number should be much larger than the number of SBHs since the production mechanism of the latter is

not *'primary'*

but

'derivative' [1].

SBHs are the result of a succession of secondary processes at much lower energies, occurring **after matter** made of protons and electrons, including the subsequently produced neutrons and stars, can exist.

The problem is to find out if the origin of the fundamental forces is all at once in the Big Bang or if the origin is in **two steps**.

The existence of the Gap is a result which implies that the gravitational force "*comes into being*" before QED, QFD and QCD.

The "***comes into being***" brings us back to **1977** when John Wheeler, after many discussions, was invited to give a series of lectures in Italy.

In the **lecture notes** [1] on page **11** he writes:

"*It is preposterous to think of the laws of physics as installed by a Swiss watchmaker to endure from everlasting to everlasting…. **The laws must have come into being***".

The mechanism of how "*The laws must have come into being*" **should indeed be studied**; it was a problem in the discussions with **Patrick Blackett** and his friend **Bertrand Russell** [22], in the fifties.

After many decades it has been **abandoned**, since **no one has been able to contribute towards a description of**

how

the Fundamental Forces

***"come into being"*.**

On page 11 Wheeler continues: "*Therefore they could not have been always a hundred percent accurate. That means that they are*

derivative,

not primary".

And on page 44: "*Of all strange features of the Universe, none are stranger than these: time is*

transcended,

laws are mutable,

and

observer-participancy matters" [1].

These notes
allow to understand what
John Wheeler
elaborated after
many successful decades
of activities in physics.

Here is a synthesis of our discussions [1]:

"*When a new idea comes in, we physicists should not start writing formulae but translate the new idea in terms of effects to be first imagined in terms of known facts. Formulae must come later*".

The wording is not exact:

the conceptual meaning is exact.

This is the reason why
we have to go on with
effects to be imagined,
before a mathematical formalism
can be worked out.

Following John Archibald Wheeler [1],
the starting point is
the new idea
(the gravitational force comes
into being before
the other fundamental forces)
first imagined in terms of known facts:
the existence of the Gap.

The mathematics needed to describe
how the Gap
can be connected with the P-SCH-objects [19]
and how
the mass spectrum of PBHs
can be derived and connected
with other effects, like the origin of the
dark matter [2] must come later [23].

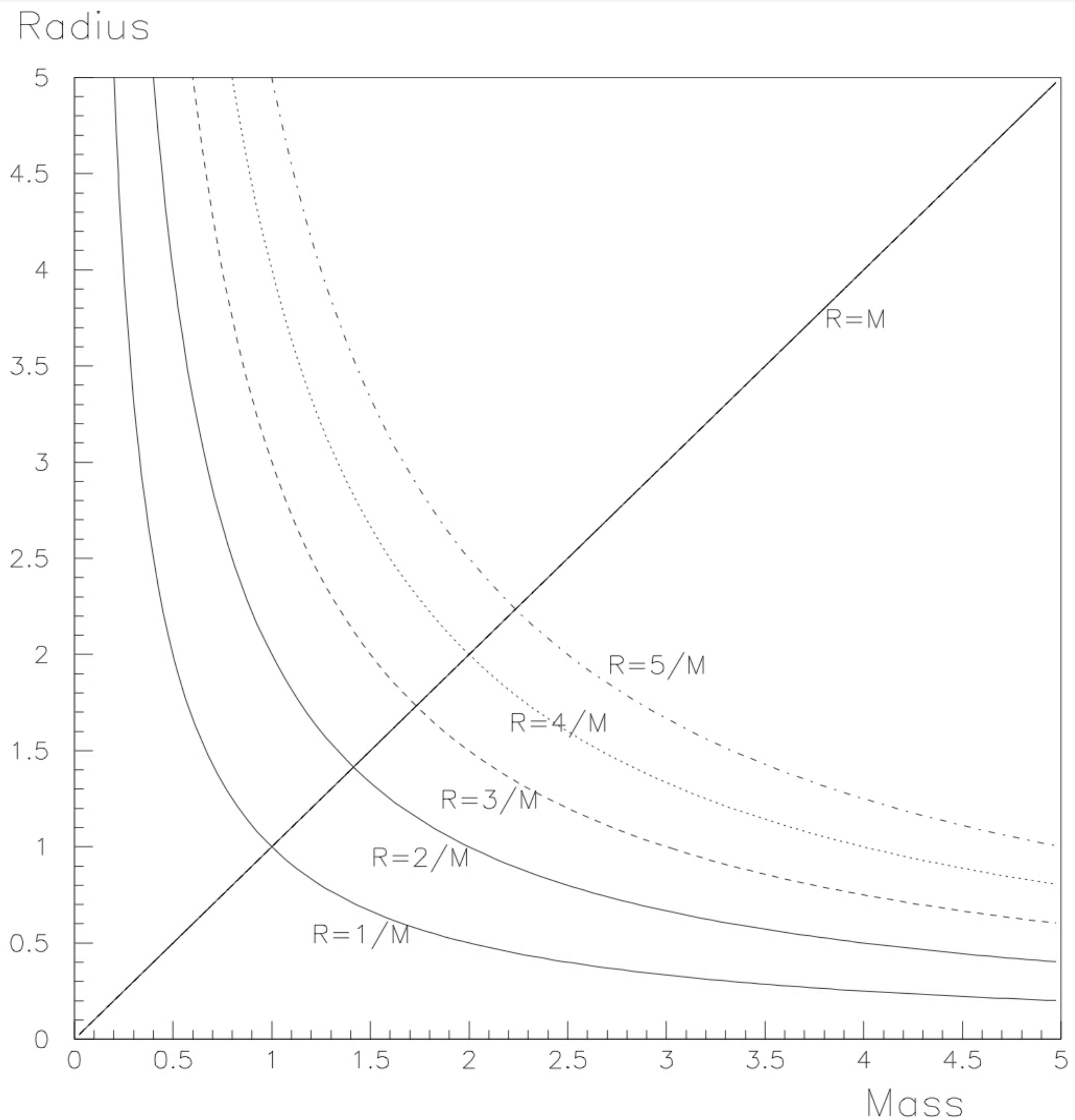
Radius
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Mass
R=M
R=5/M
R=4/M
R=3/M
R=2/M
R=1/M

Figure 3

All possible Einstein equations are represented by the function

$$\left(\mathrm{R} = \frac{1}{\mathrm{M}}\right)$$

in Figure 3.

What is needed is the function

$$\psi^{\mathrm{U}}(\mathrm{R}, \mathrm{M})$$

which evolves with Time (3) along the line $(\mathrm{R} = \mathrm{M})$ given by the Schwarzschild equation (1) [3, 6].

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RISERVA

Taking into account the advocated presence of dark matter and dark energy the total mass of the Universe could go up to about

$$\boxed{m^{\text{Universe}} \simeq 10^{58} \text{ g}.}$$

RISERVA

The Universe where we are seems to be the proof that a primordial SCH–object, starting from the Planck Universe, can expand its radius by something like 62 orders of magnitudes following the conditions dictated by the Schwarzschild solution of the Einstein equation.