String Theory and Dimensions of Subnuclear Universe

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In this paper we will show that the range of the fundamental forces which produce bound states (Gravitational, Electromagnetic and Strong Nuclear) depends on the universe in which the charges of these forces act. The dimensions of this universe and the variations of the force as a function of distance are closely related.

I. INTRODUCTION

In the 1970s, the "standard model" postulates that the universe is made up of 12 elementary particles of matter, 6 quarks and 6 leptons, and 4 particles carrying forces called mediators [1]. But this model integrates only three of the four fundamental forces. It leaves aside the fourth force, gravity which has negligible effects at the scale of elementary particles.

In 1968 string theory was born [2]. Its original goal was to reconcile General Relativity and Quantum Mechanics. It was enriched from the mid-1980s with a theory of super-strings which attempted to explain the existence of all the particles and fundamental forces of nature, by modeling them as the vibrations of tiny strings super-symmetrical. There are five versions of super-string theory, of which a main one, known as the M theory, remains today [3].

With string theory, the most fundamental components of matter in our universe, such as quarks, are therefore no longer particles, but tiny vibrating strings with a theoretical size of 10^{-34} m [4].

This theory hypothesizes that the shape of these famous strings would therefore be determined by at least ten dimensions: time with the three dimensions of our world and six other dimensions which would be so infinitely small and inaccessible because they are folded up on themselves. . The Theory M adds an eleventh spatial dimension.

The range of force of a charge is often related to the mass of its mediator. This relation cannot explain the rapid decay of the strong nuclear force which has a mediator "the gluon" with zero mass (see table below).

We will demonstrate in this paper that the range of the force (or its variations as a function of the distance) can be related to the dimensions of the universe in which its charge acts. This demonstration only applies to forces that produce bound states such as planets around stars for gravity, electrons around nucleus for electromagnetic interaction, and quark bonds in nucleons for strong interaction. Weak nuclear force is therefore excluded from this study.

II. FUNDAMENTAL FORCES

The Universe is governed by four fundamental forces: the strong force, the weak force, the electromagnetic force and the gravitational force. These forces act between charges and are carried by mediators. More precisely, the forces are due to the exchange of mediators between charges.

Force	Charge	Mediator	Mass GeV/c2	Range
Gravitational	mass	graviton	0	infinite
Electromagnétic	electrical charge	photon	0	infinite
Strong Nuclear	color	gluon	0	~10^{-15}m
Weak Nuclear	isospin	Z^0, $W^\pm$	80 à 90	~10^{-17}m

Charge and Mediator of fundamental forces

Finally, the range of gravitational and electromagnetic forces is infinite. It is very limited for the strong and weak forces which act only at the level of subatomic particles.

1. Gravitational and Electrostatic Forces

The gravitational interaction and the electrostatic interaction between two bodies are two forces proportional respectively to the product of the masses of these two bodies or to their electric charges. They have the same variation with respect to the distance between the two bodies, in $1/d^2$; their range is infinite.

The gravitational force between an electron and a proton is $2{,}27 \times 10^{37}$ times smaller than the electrostatic force (one of the two components of the electromagnetic force). It becomes dominant between macroscopic bodies because their total electric charge is neutral.

The mediators of the gravitational and electrostatic interaction are respectively the graviton and the photon, they both have zero mass.

1.1 The electrostatic force between two particles of charges « q » and « q' » is:

$$\boldsymbol{F_e} = k\frac{qq'}{d^2} = \frac{1}{4\pi\varepsilon_0}\frac{qq'}{d^2}$$

The electric field of the charge « q » is defined by

$$\boldsymbol{\mathcal{E}_q} = \frac{1}{\varepsilon_0}\frac{q}{4\pi d^2}$$

The electric field $\boldsymbol{\mathcal{E}_q}$ of a particle of charge « q » at a distance « d » represents the surface density (multiplied par the constant $1/\varepsilon_0$) of its charge on the surface of a sphere of radius « d ». This sphere is within a **3-dimensional universe** where these electrical charges act**.**

1.2 The gravitational force between two particles of mass « m » and « m' » is:

$$\boldsymbol{F_g} = G\frac{mm'}{d^2}$$

The gravitational field of mass « m » is defined by

$$\boldsymbol{g_m} = G\frac{m}{d^2} = 4\pi G\frac{m}{4\pi d^2}$$

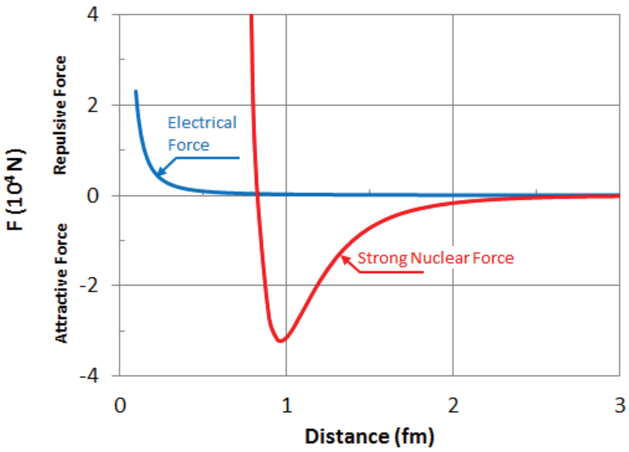
The gravitational field $\boldsymbol{g_m}$ of a particle of mass « m » at a distance « d » represents the surface density (multiplied par the constant $4\pi G$) of its mass on the surface of a sphere of radius « d ». This sphere is within a **3-dimensional universe** where these masses act**.**

Principle

When the variation of a force of charge (mass or electric charge) compared to the distance which separates these two charges is in **$1/d^2$**, this means that the effect of the charges is distributed on the surface $4\pi d^2$ of a sphere of radius « d ». This sphere is within a **3-dimensional universe** where these charges act**.**

2. Electrostatic and Strong Nuclear Forces

The repulsive electrostatic force between two protons or between two quarks of identical charges separated by10^{-15}m (= 1fm) is 100 times smaller than the strong nuclear attractive force. It becomes dominant beyond 10^{-14}m (= 10fm) because the strong nuclear force decreases 1000 times faster than the electrostatic force. The curve of variation of the strong nuclear force according to the distance is given in the diagram below.



Strong nuclear and electric force variation

This variation curve can be represented by the following equation:

$$F_{sn} = \frac{A}{d^7} - \frac{B}{d^6}$$

A and B are two positive quantities.

The strong nuclear force is therefore the sum of the two forces:

- The repulsive strong nuclear force $F_{sn1} = \frac{A}{d^7}$
- The attractive strong nuclear force $F_{sn2} = -\frac{B}{d^6}$

with $|F_{sn1}| > |F_{sn2}|$ for $d < 0{,}7$ fm.

The mediators of the strong nuclear interaction are the gluon (of zero mass) on the decreasing part of the curve (d <1fm) and the neutrino (of mass 139MeV) on the increasing part (d> 1fm).

Based on the principle stated above, we can assume that

- The effect of the "color" charge of the force $F_{sn1} = \frac{\frac{1}{3}\pi^4 A}{\frac{1}{3}\pi^4 d^7}$ is distributed over the surface $\frac{1}{3}\pi^4 d^7$ of a sphere of radius « d » located in an 8-dimensional universe.
- The effect of the "color" charge of the force $F_{sn2} = -\frac{\frac{16}{15}\pi^3 B}{\frac{16}{15}\pi^3 d^6}$ is distributed over the surface $\frac{16}{15}\pi^3 d^6$ of a sphere of radius « d » located in an 7-dimensional universe.

III. CONCLUSION

We have just demonstrated that the range of the force can be related to the dimensions of the universe in which the charges of this force act. It seems that the dimensions of this nuclear scale universe increase as we get closer to zero: 7D at 3fm ($3x10^{-15}$ m), 8D at 0,7fm ($7x10^{-16}$ m).

We can therefore suppose that at the scale of the strings (10^{-34} m) the dimensions of the universe in which the strings act (or their possible forces) will be much greater than 8. This assumption goes in the same direction as the 10D or 25D hypotheses (without the time dimension) of String Theory.

IV. REFERENCES

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