First evidence for a scalar-tensor theory of gravity

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Abstract

I report experimental evidence for torque caused by a magnetic impulse on a non-magnetic torsion pendulum. This is well understood as a pulsed gravitational potential, χ, generated by a transient magnetic field as predicted by an improved Kaluza-Klein theory stabilized by an external real scalar field, ψ. Such a theory, dubbed the KKψ, allows an enhanced coupling of its fundamental long range real scalar field, ϕ, as well as its external one, ψ, to the electromagnetic field. The experiment is consistent with the KKψ theory.

Present status of experimental gravity

Gravitation waves are predicted by General Relativity and a clue to their existence are provided by the observational data from the binary pulsar PSR 1916 + 13.

However, despite the great sensitivity and noise reduction achieved with the laser interferometric detectors such as LIGO, VIRGO and GEO 600, no evidence of any single signal from a gravitational waves source has been detected until now.

Of course this is not sufficient to rule out the existence of gravitational waves. It may be that the interferometric

detectors are not as easy to handle as it was initially thought.

The nature of dark energy is still a mystery.

In addition, there is no indication of SUSY at the LHC and no clear detection of dark matter from undergound bolometers worldwide.

Even inflation, which involves a scalar field, has not been really confirmed.

The only fundamental scalar particle observed yet is the Higgs boson (2012) whose associated field is short range and gives their masses to elementary particles.

The gravitation constant is the less precise universal constant measured nowadays. Although the precision is improving in each laboratory the overall values of the different laboratories are more and more discordant.

Furthermore, no theory of quantum gravity is avalaible yet.

Superstring theory provides no testable prediction at the low energy achieved in present day laboratories.

Loop quantum gravity makes some predictions but none has been observed yet.

Instability of the genuine Kaluza-Klein theory

The genuine Kaluza-Klein (KK) theory is unstable both in the Einstein and Jordan frames.

The 5D KK theory with zero electromagnetic field equivalent to a Brans-Dicke theory with parameter $\omega = 0$. Now, as shown by Noerdlinger (1968), stability of the Brans-Dicke action requires $\omega > 0$.

The limiting case $\omega = 0$ leads to an unstable vacuum (Constantinidis, Fabris, Furtado and Pico, 2000).

Along with M. Lachieze-Rey, we have suggested (1997-2004) to cure this instability of the KK theory by introducing an external scalar field, ψ, we dubbed this improved theory the KKψ theory.

Then we turn to the experiments and observations to test this theory.

The KKψ theory as a possible solution to classical gravity conundrum

Many theories which include extradimensions have been proposed as candidates for the unification of physics. As such, they involve a coupling between gravitation and electromagnetism (GE coupling), as well as with other gauge fields present.

The discrepancy between the present results of the gravitational constant measurements may be understood as a consequence of the GE coupling in the sense that experiments yield $G_{eff} = G/\Phi$ instead of the true G.

Out of the scalar fields' source, but in presence of a static dipolar magnetic field, $\mathbf{B} = \nabla V(r, \phi, \theta)$, one finds

$$\Phi = 1 - (\mu_0 \digamma)^{-1} V^2,$$

since $\Delta V = \mathrm{div}\, \mathbf{B} = 0$.

From the fit to a sample of 44 most precise measurements, one derives both estimates of :

the true gravitational constant

$$G = (\ 6.6696 \pm 0.0008\ ) \times 10^{-11}\ \mathrm{m}^3\ \mathrm{kg}^{-1}\ \mathrm{s}^{-2}$$

and the coupling parameter

$$\mathsf{F} \approx [(5.44 \pm 0.66) \times 10^{-6}\ \mathrm{fm} \cdot \mathrm{TeV}^{-1}]^{-1}$$
$$\approx (2.99 \pm 0.36) \times 10^{13}\ \mathrm{N}.$$

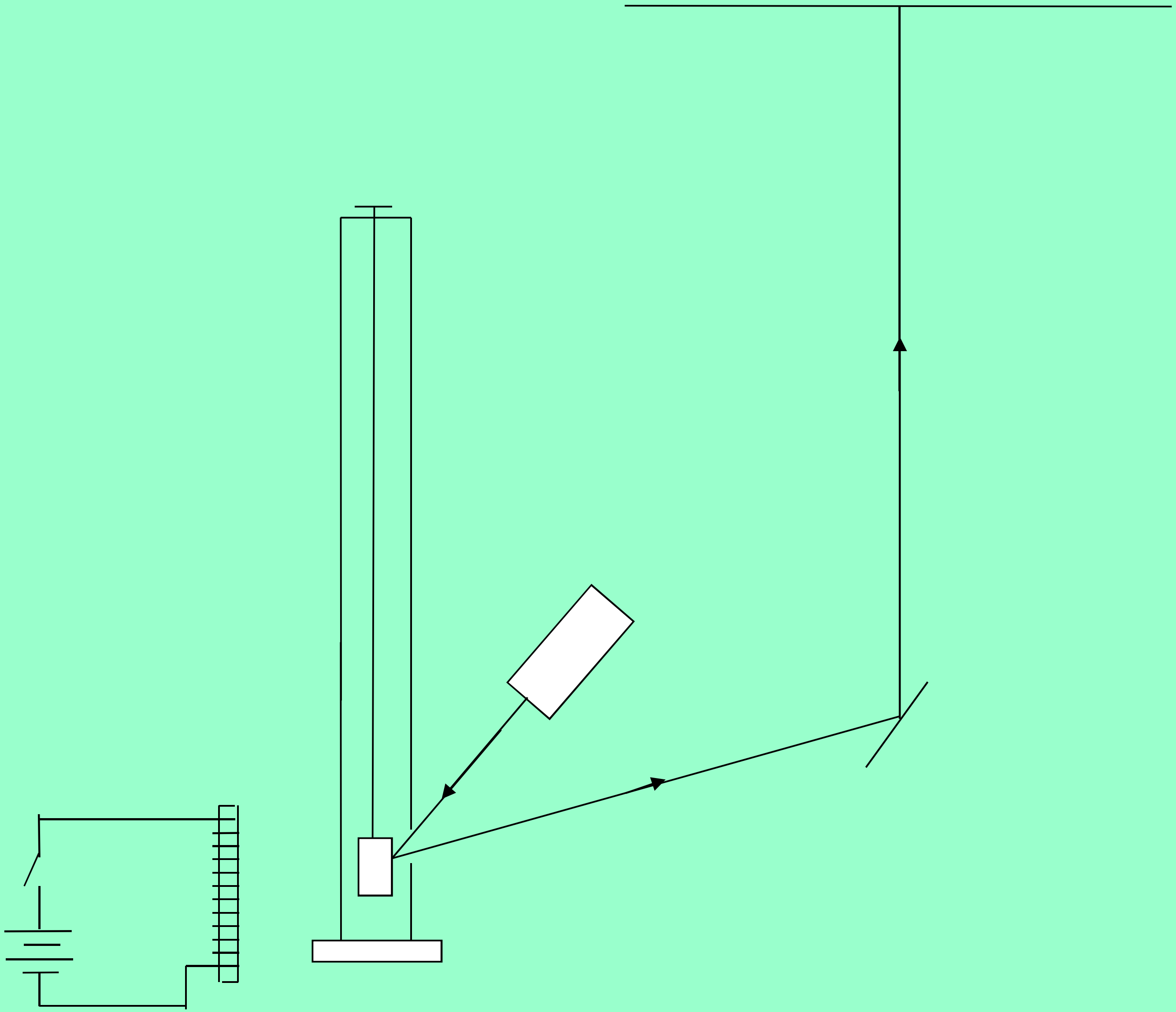
Recently, F. Minotti (2013-2014) have used the KKψ theory to explore the possibility of explaining the forces reported on asymmetric resonant cavities, using the same coupling, F, reported to explain discordant measurements of G.

He also found that there is an additional bonus in the inclusion of the external scalar ψ, in that it could reconcile the solar system tests with small values of the Brans-Dicke parameter, ω.

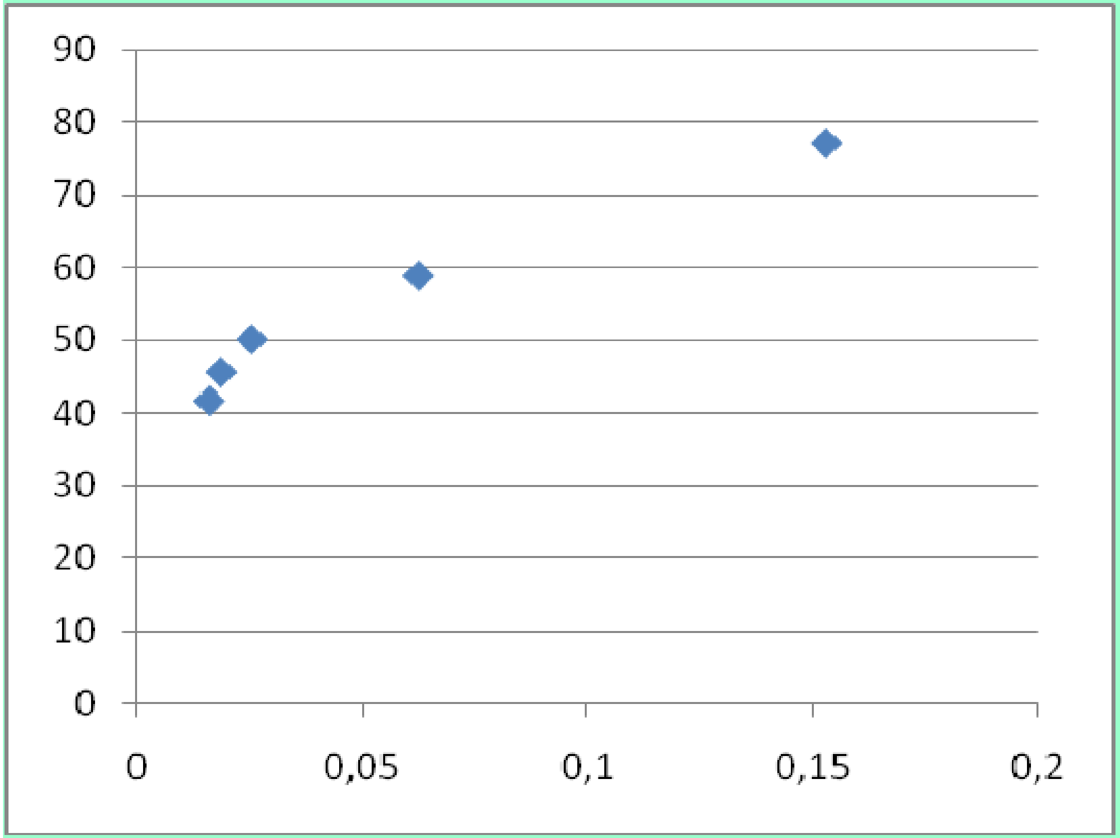
Then, along with T. Raptis, F. Minotti suggested very interesting experiments to test the KKψ theory.

Following their suggestion, I have performed a variant of the proposed experiment and found positive results.

Schematic of the experimental setup



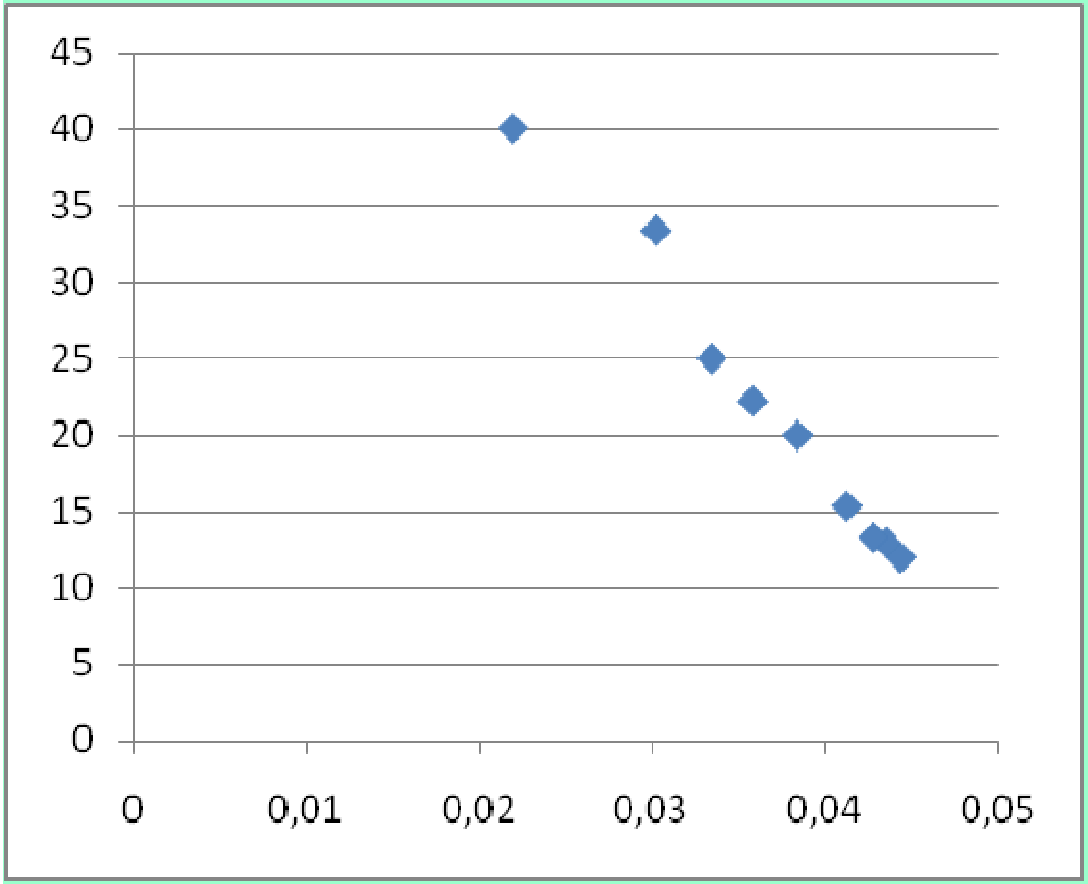
Experimental data



I(A)	d_{max}(cm)
1.6	1.3
2.0	1.7
2.5	2.0
2.7	2.2
2.8	2.4

Plot of $d_{max}(m)^{-1}$ versus $I(A)^{-4}$. One finds $d_{max}{}^{-1} = 209.9\ I^{-4} + 45.07$,
consistent with the theoretical prediction $\theta_{max}{}^{-1} = (r^2/4XY)\ (\omega_S\ \omega_T\ R^4/c^4)\ (F\ r^2\ \mu_r{}^2/l\ L)^2\ I^{-4} + (X/Y)$,
for $X = -23$ cm and $Y = -0.3$ mm (measurement gives $Y = -0.25 \pm 0.05$ mm),
with reduced chi-square $\chi_\nu{}^2 = 0.923$ on account that $\delta d_{max} = 2$ mm.

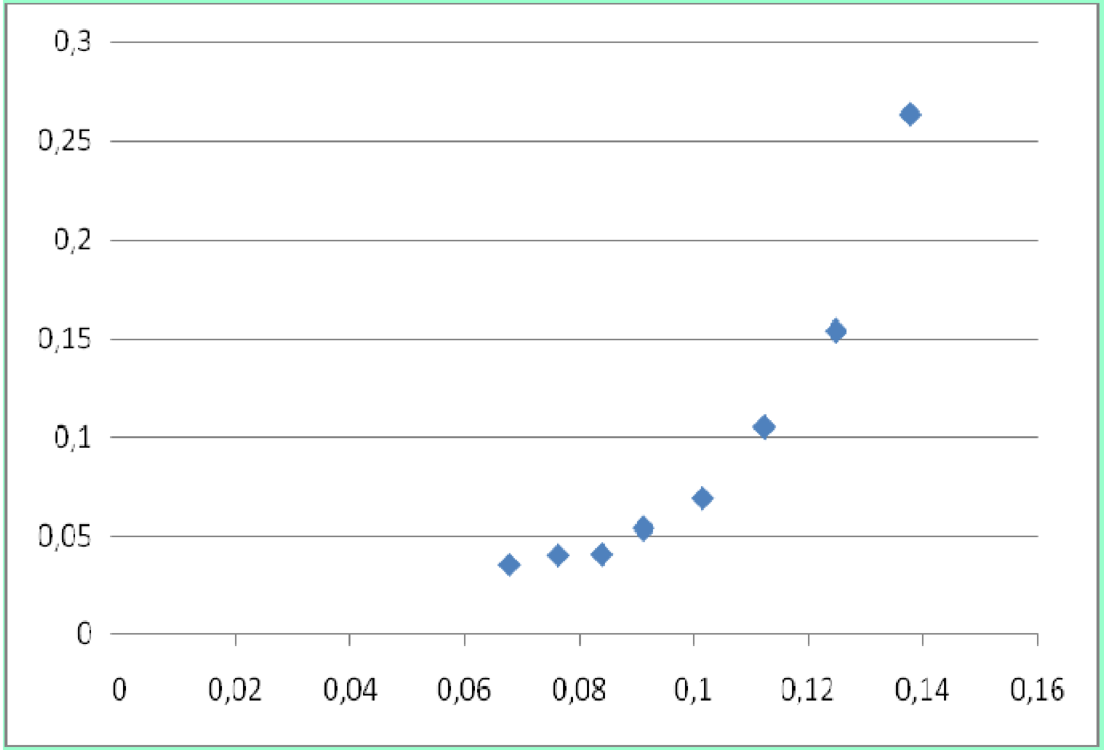
Experimental data



I(A)	d_{max}(cm)
2.6	2.5
2.4	3.0
2.34	4.0
2.3	4.5
2.26	5.0
2.22	6.5
2.20	7.5
2.19	7.7
2.18	8.3

Plot of $d_{max}(m)^{-1}$ versus $I(A)^{-4}$ during the decline of the current flowing through the coil. One finds $d_{max}^{-1} = -1252\, I^{-4} + 67.2$, consistent with the theoretical prediction $\theta_{max}^{-1} = -(r^2/4XY)(\omega_S\, \omega_T\, R^4/c^4)(F\, r^2\, \mu_r^2/l\, L)^2\, I^{-4} + (X/Y)$, for $X = -23$ cm and $Y = -0.2$ mm (measurement gives $Y = -0.25 \pm 0.05$ mm), with reduced chi-square $\chi_\nu^2 = 0.810$ on account that $\delta d_{max} = 2$ mm.

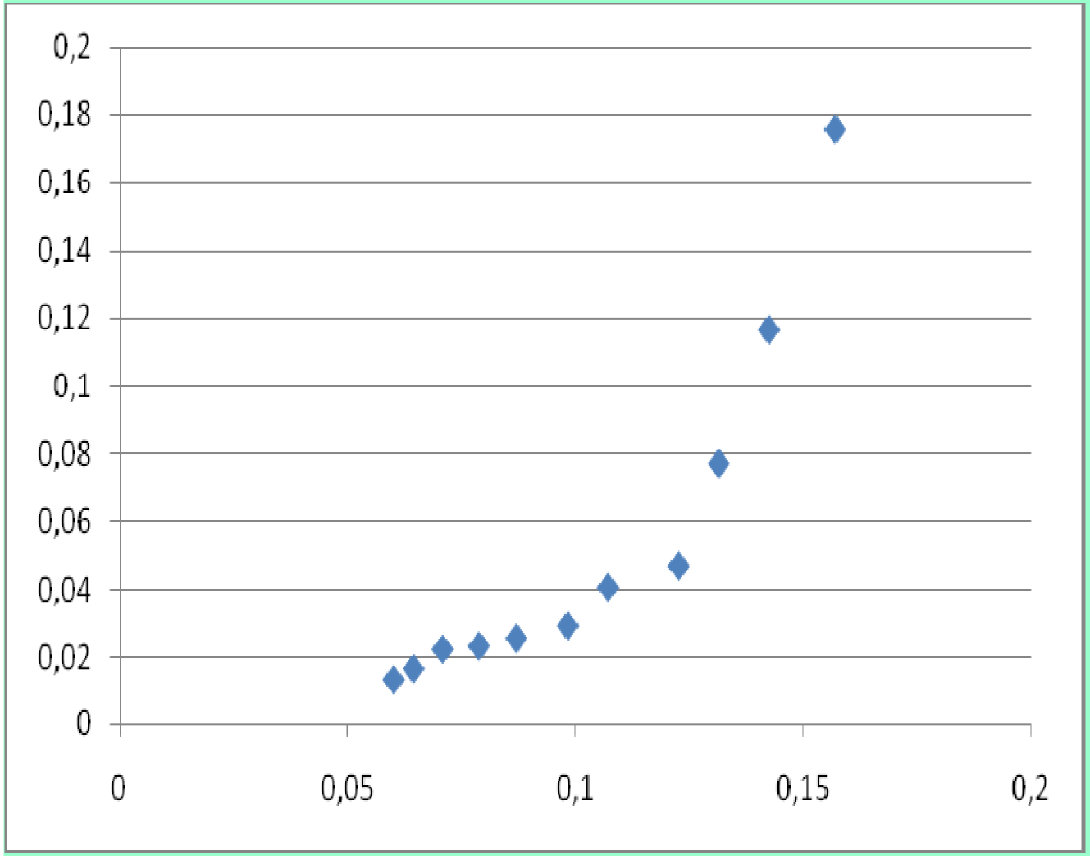
Experimental data



U(V)	I(A)	d_{max}(cm)	Δt(min)
19	1.641	3.8	14
20	1.682	6.5	20
21	1.727	9.5	22
22	1.771	14.4	23
23	1.819	18.5	2
24	1.857	24.4	21
25	1.902	24.7	35
26	1.959	28.1	32

Plot of $d_{max}(m)^{-1}$ versus $I(A)^{-4}$, one finds $d_{max}{}^{-1} = 298.7\, I^{-4} - 20$..
Coil axis parallel to the x-axis. The bob, of mass m = (35.5 ± 0.1) g, is a rectangular parallelepiped uncolored PMMA sheet (side length of 10 cm and thickness 2 mm) attached to a wire of length l = 17 cm ; Δt denotes the measuring time.

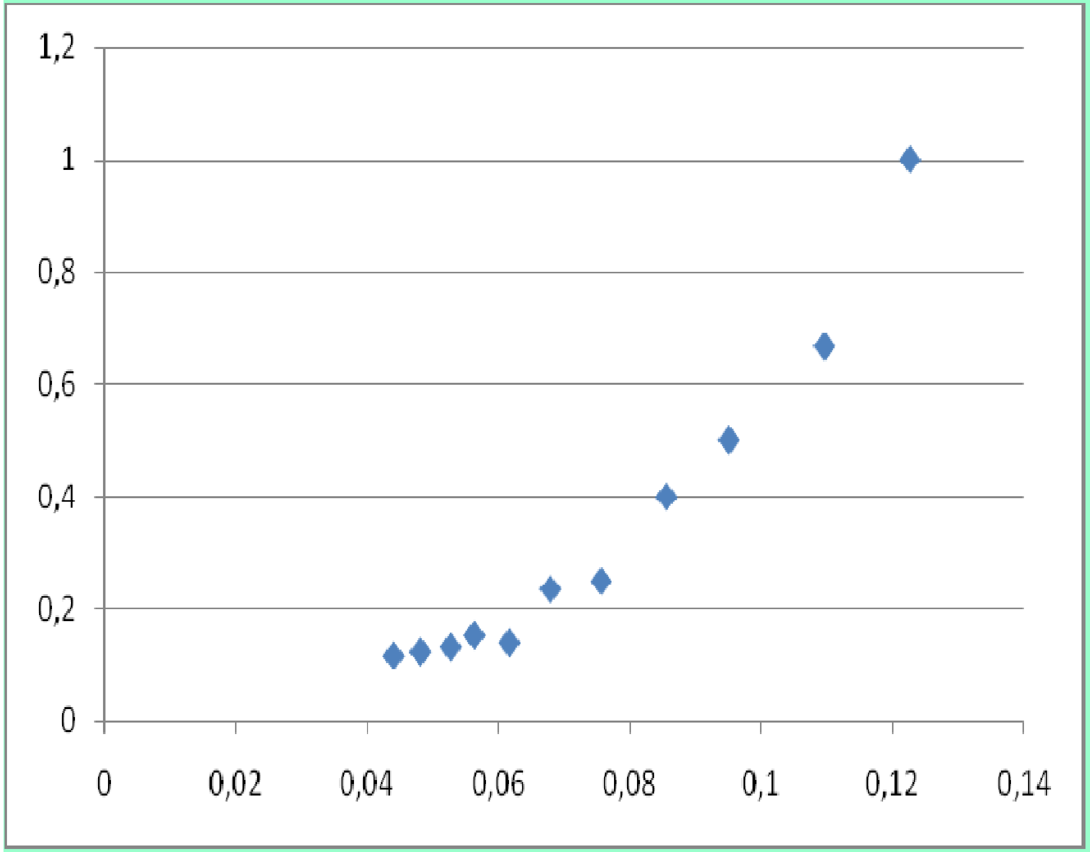
Experimental data



U(V)	I(A)	d_{max}(cm)
18	1.589	5.7
19	1.628	8.6
20	1.661	13
21	1.690	21.4
22	1.748	24.7
23	1.786	34.7
24	1.841	39.7
25	1.887	43.6
26	1.938	45.4
27	1.984	61.2
28	2.019	75.9

Plot of $d_{max}(m)^{-1}$ versus $I(A)^{-4}$, one finds $d_{max}{}^{-1} = 138.2\ I^{-4} - 8.76$.
Coil axis parallel to the y-axis in such a configuration that reduces significantly the magnetic flux through the bob. The bob, of mass m = (35.5 ± 0.1) g, is a rectangular parallelepiped uncolored PMMA sheet (side length of 10 cm and thickness 2 mm) attached to a wire of length l = 17 cm.

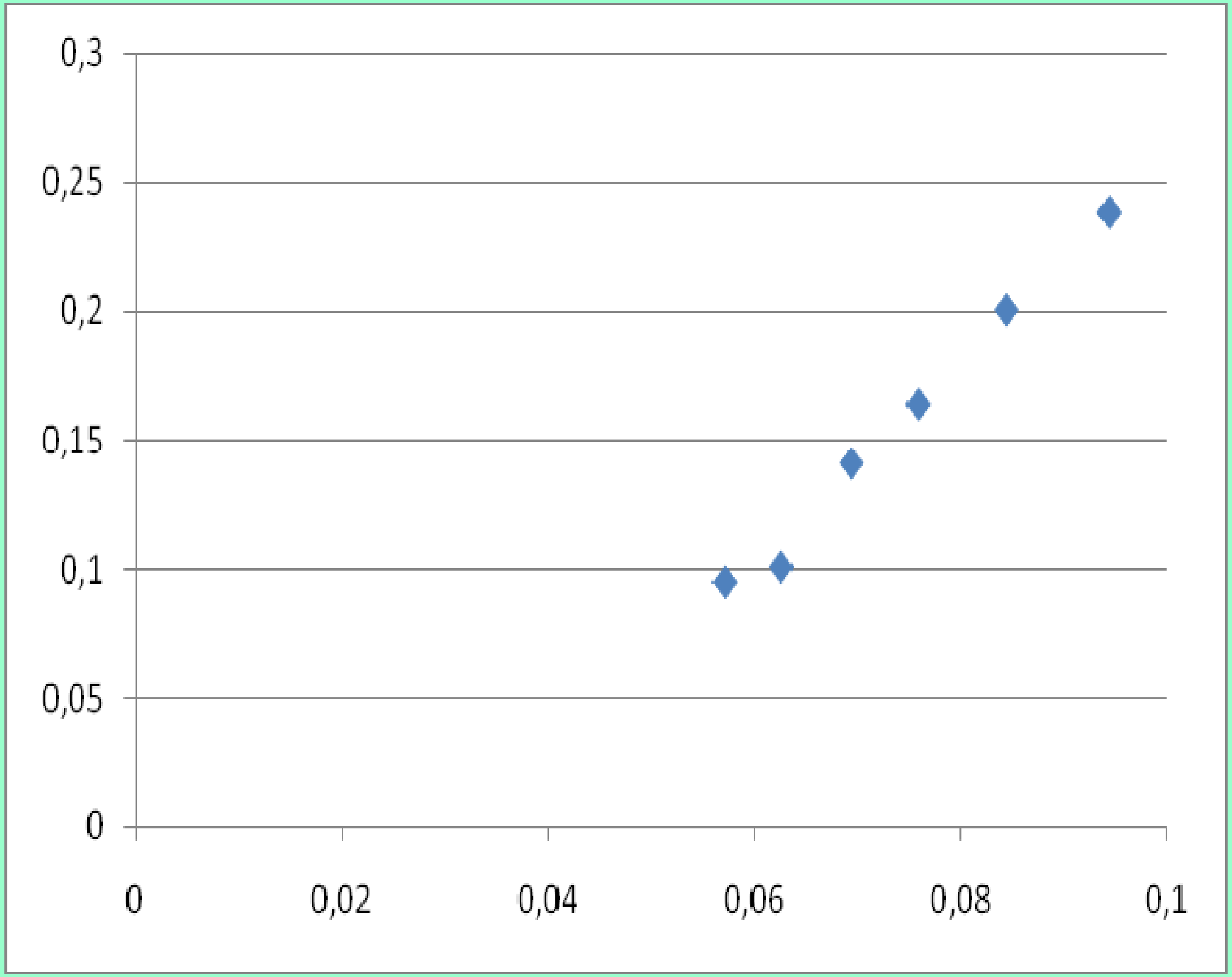
Experimental data



U(V)	I(A)	d_{max}(cm)	Δt(min)
21	1.690	1	68
22	1.738	1.5	42
23	1.801	2	30
24	1.849	2.5	22
25	1.907	4	20
26	1.959	4.25	20
27	2.007	7.1	27
28	2.053	6.5	23
29	2.087	7.5	40
30	2.135	8	26
31	2.183	8.5	22

Plot of $d_{max}(m)^{-1}$ versus $I(A)^{-4}$, one finds $d_{max}^{-1} = 1050\ I^{-4} - 44.33$.
Coil axis parallel to the x-axis and coil above the chamber of the pendulum at about 35 cm height
Such a configuration allows no significant magnetic flux through the bob.
The bob, of mass m = (35.5 ± 0.1) g, is a rectangular parallelepiped uncolored PMMA sheet.

Experimental data



Plot of $d_{max}(m)^{-1}$ versus $I(A)^{-4}$, with the axis of the coil being parallel to the y-axis.
The experiment was performed with a bob made of glass of mass $m = (43.2 \pm 0.1)$ g.
One finds $d_{max}^{-1} = 401.7\ I^{-4} - 14.08$, still consistent with the theoretical prediction.
The current was varied from I = 1.756A to 2.090A ; Δt = 6 min to 23 min.

CONCLUSION

The KKψ theory predicts a variation of the effective fine structure "constant" α with the gravitational field, and thus with the cosmological time,

It also fits quite well the rotational curves of spiral galaxies and sets new correlations.

Besides, it seems now that experimental supports the KKψ theory. However, one should keep in mind that this is just a low energy limit of a more fundamental theory. Perhaps a new interpretation of either superstring theory or loop quantum gravity.

THANK YOU FOR YOUR ATTENTION !

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