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Surrounding principle applied to Yang-Mills theory: introduction

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Abstract. The method here is to use the principles of the Gravitational Model of the Three Elements Theory (GMTET) in the context of particle physics. The GMTET equations are simplified, following the simplifying principle used for Surrounding Matter Theory (SMT) which is handling only gravitation. But applying this simplifying principle to the 3 remaining forces yield a set of 3 equations. Like in SMT, they are also modified by inserting an undimensional correcting factor involving matter density located at the location where the forces are exerted. For Electroweak force and Electromagnetism the modification implies the intra-atomic scale. For the strong force the derived interaction law is not restricted in scale and yield a confinement. Another result is the simple cancellation of the color of the attracting particle, in the modified equation of the attracting force. In vacuum this shows the apparition of a mass gap in the interacting spectrum. Compliance of the model with other parts of physics, noticeably particle physics experimental results, remains to be checked. But compliance with relativity is achieved. Moreover this modification is compliant with an extension of relativity which is in accordance with Mach's principle, and avoidance of singularities.

Keywords: quantum mechanics, quantum chromodynamics, yang-mills, confinement, mass gap

1 Introduction

Surrounding Matter Theory (SMT) [1] has shown that an extension of General Relativity (GR) might be possible, producing interesting predictions at large scale. Here the attempt is to use the same extension principle in the field of particle physics. The resulting model behaves like the Yang-Mills theory modified by a correcting factor depending only of matter density at the location where the forces are exerted. The result appears quickly to behave like an easy solution to the Yang-Mills Millenium problem [2]. But coherence of this mechanism for the 3 forces must be achieved. And regression of physics must be thoroughly checked. In this document this new model will be named Particle Surrounding Matter Theory (PSMT).
A reminder of the Gravitational Model of the Three Elements Theory (GMTET) [3] is done. It is followed by the description of its simplification, and then its application to each of the 3 remaining forces after gravitation. Then a focus on the strong interaction is quickly done.

2 GMTET reminder

The implicit principle of GMTET is that each of the 4 forces might be generated by space-time deformations. Hence the famous GR principles are extended from gravitation to the 3 other forces: space-time deformation by energy principle, and "following geodesics" principle. What will defer between the forces will be the exact local repartition of energy in the physical objects involved by the force. But another equivalent way to understand those principles is the following. Gravitation in this model can be seen as the only existing force, acting at the microscopic level. And then the 3 remaining forces are just a macroscopic effect of gravitation. Their differences with gravitation are due to a difference in the internal microscopic energy distribution involved in the particles.

This principle yields, in a straightforward manner, a modification of this fundamental gravitation force. This has been discussed in [1] and [3].

And this modification can be divided into 2 consecutive modifications. In this document, what is called in [3] the “first modification” will not be taken into account. A reason for this is that the value of this first modification is low, in the order of magnitude of the Pioneer anomaly. This range of its relative correction does not impact the usual domain of particle physics.

3 Application of GMTET to particle physics in this document

Therefore in this document what is called the “second modification” of Newton’s law in [3] will only be taken into account. In that sense the same dynamic as SMT [1] dynamic might be expected.

GMTET predicts an anisotropy of the gravitational force. This will be not be reconducted here. More precisely, in GMTET the gravitational force depends of the orientation of the line of attraction between the 2 involved particles. But for simplification of the calculations, a simple equation will be used here, which yields only an isotropic behavior.

The simplest way to understand PSMT is simply to start from Yang-Mills equations, and suppose that relativity is extended by GMTET. Here this extension involves only a “SMT like” modification, rewritten appropriately for particle physics. This rewriting will be described in this document. Then a fundamental $1/x^2$ law is supposed for the 4 forces, in case of a constant matter density. This $1/x^2$ law is the prediction of GR for gravitation involving particles but in the particular case of constant matter density, it is also the prediction of GR extended by SMT. This $1/x^2$ square result will be supposed valid for the 3 remaining forces, also, in this case of constant matter density.

4 Sophisticated application of GMTET to particle physics

A more sophisticated version would be to model precisely the complete GMTET theory, that is, to describe the composition of each existing particle in the GMTET model. The trajectory of luminous points inside each particle would be detailed. And the aim would be to retrieve the whole particle physics from this complete GMTET. This is a huge work and a huge result. This “complete” GMTETis a unifying theory which is also named “Three Elements Theory” (TET).But today, the description of TETis in a version which is much too rough and qualitative. Needless to say that this is not the aim of this document.

5 The modification

The GMTET correction is the following. It starts from a classical potential for each of the 4 forces, given by equation (1).

$$\Phi = \alpha \frac{m_a m_b}{x} \tag{1}$$

α is the constant depending of the concerned interaction. This potential corresponds to the force generated by a given pA particle of charge $\boldsymbol{m_a}$, located on the A point, exerted on another pB particle of charge$\boldsymbol{m_b}$, located on a B point. Those charges are either Coulomb charge, weak interaction charge, or color, depending of the considered interaction.$\boldsymbol{x}$ is the distance between the 2 particles. From it, the following new potential is calculated, incorporating the PSMT modification.

$$\Phi \;=\; \alpha \frac{m_a m_b}{x} \underbrace{\frac{\rho_2}{\rho+\rho_1}}_{C_{PSMT}} \tag{2}$$

In this document only the overall behaviour of the model is searched for. It will be supposed that the inserted factor $\boldsymbol{C_{PSMT}}$ is a scalar, not an operator. Therefore no quantization will be done for $\boldsymbol{C_{PSMT}}$.

$\rho$is given by the following equation.

$$\rho \;=\; \frac{1}{8\pi\sqrt{x_{max}}} \int_{S_{max}} \frac{\rho(x)}{d(x,O)^{\frac{5}{2}}} d^3x \tag{3}$$

$\rho(\boldsymbol{x})$ is the matter density at the $\boldsymbol{x}$ vectorial location, without taking in account the mass of pB.

$\boldsymbol{d}(\boldsymbol{x},\boldsymbol{O})$is the distance between the $\boldsymbol{x}$ location and the B point.

$\boldsymbol{x_{max}}$ is a constant having the units of a length. It is the maximum length at which the calculation ofρ ends.

$\boldsymbol{S_{max}}$is the sphere centered on the B point, of ray$\boldsymbol{x_{max}}$, therefore the sphere in which the calculation of $\rho$is done.

The method at the creation of this equation is that it must express matter density in the surrounding area of the location where the force is exerted. But this expression must yield a continuous behavior, and a finite value for any physical case. That's why this equation is quite complicated. It might be replaced by another version, having the goals above achieved. And this would not change the results which are studied in this document.

Lets' explain quickly the motivation for the details of this equation. The tough question when elaborating this equation was: "which particle must be taken into account when calculating this matter density ?". It sounds natural to exclude the particle which is receiving the attracting or repulsing force, here, pB. This would be a self-generated effect.

$\rho_1$and ρ_2 are constants, with units of a matter density.

Each of $\alpha, \rho_1, \rho_2, \boldsymbol{x_{max}}$depends of the considered interaction. For example, there will beα_e for QED,$\alpha_w$for weak interaction , and$\alpha_s$for strong interation. The values of $\rho_1$and $\boldsymbol{x_{max}}$ are indicated in the following table.

Constant/Force	msitengamortcelE	noitcaretni kaeW	noitcaretni gnortS
α	Positive	Positive	Negative
ρ_1	1 $\boldsymbol{kg/m^3}$	1 $\boldsymbol{kg/m^3}$	0
ρ_2	1 $\boldsymbol{kg/m^3}$	1 $\boldsymbol{kg/m^3}$	1 $\boldsymbol{kg/m^3}$
$\boldsymbol{x_{max}}$	1 $\dot{\boldsymbol{A}}$	1 $\dot{\boldsymbol{A}}$	1 $\dot{\boldsymbol{A}}$
Turning point (deduced)/force	msitengamortcelE	noitcaretni kaeW	noitcaretni gnortS
$\boldsymbol{x_t}$	3 $\dot{\boldsymbol{A}}$	3 $\dot{\boldsymbol{A}}$	∞

Table 1 : values of the parameters of equation (2)

But in this document, the letters$\alpha, \rho_1, \rho_2, \boldsymbol{and} \boldsymbol{x_{max}}$will be used, and the context will tell their exact signification.

Of course, the exact equation is the relativistic formulation of equation (2), handling only Lorentz invariants:

$$\boldsymbol{R_{\mu\nu}} - \frac{1}{2}\boldsymbol{R g_{\mu\nu}} = \boldsymbol{\kappa S_{\mu\nu}}$$

$$\boldsymbol{S_{\mu\nu}} = \boldsymbol{C^l_\mu C^m_\nu T_{lm}} \tag{4}$$

$$\boldsymbol{C^\nu_0} = \sqrt{\boldsymbol{C_{PSMT}}}\,\delta^\nu_0 \qquad \boldsymbol{C^\nu_i} = \sqrt{\boldsymbol{s}}\,\delta^\nu_i$$

$\boldsymbol{c}$ is the speed of light,$\boldsymbol{R}_{\mu\nu}$ is the Ricci tensor,$\boldsymbol{g}_{\mu\nu}$ is the metric, $\boldsymbol{g}$ is the trace of$\boldsymbol{R}_{\mu\nu}$. $\delta_{\mu\nu}$are Kronecker symbols and $\boldsymbol{i}$indice is varying between 1 and 3. Equations (4) show that$\boldsymbol{C}_{\mu}^{\nu}$is a time dilation by the$\sqrt{\boldsymbol{C}_{PSMT}}$ factor, and a space dilation by the$\sqrt{\boldsymbol{s}}$ factor, $\boldsymbol{s}$ being a positive scalar. Of course, there are 3 versions of the system of equations (4), one for each of the 4 forces. $\boldsymbol{\kappa}$is a constant which is proportional toα. For calculating $\boldsymbol{s}$, $\nabla^{\mu}\, \boldsymbol{G}_{\mu\nu} = \mathbf{0}$is needed as well as the limit cases of equations (4). The non relativistic case, simply transforms equations (4) into equation (2). And the "constant surrounding matter density over space-time" case transforms equations (4) into 4 systems of equations which are similar to Einstein equation, for the 4 forces. (These 4 final systems of equations are yielded starting from those equations (4), and supposing$\boldsymbol{C}_{\mu}^{\nu}$ constant). As usual, through any Lorentz transform, the value of$\boldsymbol{C}_{PSMT}$ is constant since its numerator and denominator are multiplied by the same Lorentz coefficient. In this document it will be considered only non-relativistic interactions, therefore only equation (2) will be used. The Yang-Mills Lagrangian is of course modified accordingly. The$\boldsymbol{C}_{PSMT}$ coefficient is inserted, multiplying twice each term of the Lagrangian, and another term in the Lagrangian is appearing, exactly like in [1].

Let's use the following relation between the expectation value of the position (the X vector in space), the $\boldsymbol{m}$mass of the attracted object, the expectation value of the potential gradiant.

$$\frac{d}{dt}\left(m\frac{d}{dt}\langle X\rangle\right) = -\langle\nabla\Phi\rangle \qquad (5)$$

The expectation value of the force is:

$$\langle F\rangle = -\langle\nabla\Phi\rangle \qquad (6)$$

Now derivating equation (2) and using equation (5) for calculating the attracted force exerted on B, will yield the following.

$$M_b\frac{d^2}{dt^2}\langle x\rangle = -\langle\frac{d\Phi}{dx}\rangle \qquad (7)$$

$\boldsymbol{M}_b$ is the mass of pB, which will be supposed constant. It has been written $\boldsymbol{x}$, the distance between A and B. It has been supposed that A is much heavier than B.

$$\frac{d^2}{dt^2}\langle x\rangle = -\alpha\rho_2 m_a\frac{m_b}{M_b}\langle\frac{1}{x^2}\frac{\rho+\rho_1+x\frac{\partial\rho}{\partial x}}{(\rho+\rho_1)^2}\rangle \qquad (8)$$

It has been supposed that$\boldsymbol{m}_b$is constant.

6 General statement for the 3 interactions

It will be supposed the following approximations.

1. The size $\boldsymbol{x}_a$ of pA is a constant and not a quantified value,
2. $\boldsymbol{x}_a$ (the scale of the nucleus of atom) is far weaker than $\boldsymbol{x}_{max}$: $\boldsymbol{x}_a \ll \boldsymbol{x}_{max}$,
3. matter density inside of pA is contant.

6.1 High energy

If pA is closed to pB, compared to $\boldsymbol{x_a}$, that is: $\boldsymbol{x < x_a}$, then there is, from equation (3):

$$\rho \cong \rho_a \sqrt{\frac{x_a}{x_{max}}} \tag{9}$$

Since $\boldsymbol{C_{PSMT}}$ is supposed to be a unquantified scalar, from equation (8) there is the following.

$$\frac{d^2}{dt^2}\langle x\rangle\Big|_{x<x_a} \cong -\alpha m_a \frac{m_b}{M_b} \frac{\rho_2}{\rho_1 + \rho_a \sqrt{\frac{x_a}{x_{max}}}} \langle \frac{1}{x^2} \rangle \tag{10}$$

And the acceleration is not varying very much.

6.2Intermediate mode

Now it will be supposed that pA is not closed to pB, compared to $\boldsymbol{x_a}$, that is: $\boldsymbol{x > x_a}$. But it is supposed nevertheless that $\boldsymbol{x < x_{max}}$. It results the following.

$$\rho = \frac{m_a}{8\pi\sqrt{x_{max}}} x^{-\frac{5}{2}} \tag{11}$$

$$\frac{d^2}{dt^2}\langle x\rangle\Big|_{x_a<x<x_{max}} = -\alpha \rho_2 m_a \frac{m_b}{M_b} \langle \frac{1}{x^2} \frac{\rho_1 - \frac{3}{2} k x^{-\frac{5}{2}}}{\left(\rho_1 + k x^{-\frac{5}{2}}\right)^2} \rangle \tag{12}$$

It has been used $\boldsymbol{k} = \frac{m_a}{8\,\pi\sqrt{x_{max}}}$. This mode must be refined, depending on the exact concerned force. This will be done below.

6.3Low energy

Now it will be supposed that$\boldsymbol{x > x_{max}}$.It will be supposed that $\rho(\boldsymbol{x})$, therefore ρ also, has a constant and low value. It results the following.

$$\frac{d^2}{dt^2}\langle x\rangle\Big|_{x_{max}<x} = -\alpha m_a \frac{m_b}{M_b} \frac{\rho_2}{\rho_1 + \rho_0} \langle \frac{1}{x^2} \rangle \tag{13}$$

7 Electromagnetism and Weak interaction

In the intermediate mode, for weak and electromagnetic interactions, since$\rho_1 \neq \boldsymbol{0}$, there is a turning point $\boldsymbol{x_t}$for the distance, $\boldsymbol{x}$, which is given by the following equation.

$$\boldsymbol{x_t} = \left(\frac{m_a}{8\,\pi\rho_1\sqrt{x_{max}}}\right)^{\frac{2}{5}} = 3\ \dot{\mathrm{A}} \tag{14}$$

For $\boldsymbol{x}$ greater than $\boldsymbol{x_t}$, equation (12) is the following.

$$\frac{d^2}{dt^2}\langle x\rangle\Big|_{x_a<x<x_{max}} \cong -\alpha m_a \frac{m_b}{M_b}\frac{\rho_2}{\rho_1}\langle\frac{1}{x^2}\rangle \tag{15}$$

The 1/x² law is retrieved. And for $\boldsymbol{x}$ weaker than $\boldsymbol{x_t}$, equation (11) is the following.

$$\frac{d^2}{dt^2}\langle x\rangle\Big|_{x_a<x<x_{max}} \cong 12\pi\alpha\rho_2 \frac{m_b}{M_b}\sqrt{x_{max}}\langle\sqrt{x}\rangle \tag{16}$$

For Electromagnetism orweak interaction, since $\boldsymbol{x_t}$ is of the order of the ray of an atom, equation (13) is valid. Of course the value $\boldsymbol{x_t}$ might be lowered by tuning the model if needed. And this equation is the classical physics equation for Electromagnetism and eventually for the weak interaction. Therefore PSMT is not predicting any departure from actual physics for those 2 interactions. But equation (14) shows that singularities can no longer appear in this new model.

8 Strong interaction

8.1 Confinement

For the strong interaction, there is no turning point in the intermediate mode. Since $x_a < x < x_{max}$ is valid for the usual experimental tests of the strong interaction, it can be deduced directly from equation (12) the following result.

$$\frac{d^2}{dt^2}\langle x\rangle\Big|_{x_a<x<x_{max}} \cong 12\,\pi\,\alpha\rho_2 \frac{m_b}{M_b}\sqrt{x_{max}}\langle\sqrt{x}\rangle \tag{17}$$

This is an atttraction since α is negative here. The mean value of the force does not depend anymore of the mass of the attractor, $\boldsymbol{m_a}$, but is still proportional to the mass of the attracted object. Equation (17) tells us that the mean value of this force is proportional to the mean value of the square root of the distance between the 2 particles, if the 2 particles are supposed to have constant masses and colors. This gives an explanation for confinement. The physical explanation is that, when the 2 particles are far from each other, matter density is low and interactions are stronger. This is due to the GMTET phenomenon: decreasing matter density at the location where the interaction is calculated, results in a increase of the involved space-time deformations, and thereafter results in an increase of the interaction. This behavior is acting also in SMT [1], but at very large scale.

Of course this phenomenon must be added to any classical "screening" mechanism.

Like for the weak and electromagnetic force, equation (17) shows that singularities can no longer appear in this new model.

8.2 Possible regressions

The main apparent regression which might be tested now is the absence of the mass of the attractor in the expression of the mean value of the force. It might have no strong incidence in the major cases, involving the strong interaction between 2 or more quarks.

Another regression might occur for high distances. Indeed, for $\boldsymbol{x}$ greater than $\boldsymbol{x_{max}}$, therefore for the low energy mode, equation (3) yields a constant matter density, and the predicted interaction force (equation (8)) is the following.

$$\frac{d^2}{dt^2}\langle x\rangle\Big|_{x>x_{max}} \cong -\alpha m_a \frac{m_b}{M_b}\frac{\rho_2}{\rho}\langle\frac{1}{x^2}\rangle \tag{18}$$

Therefore, for $\boldsymbol{x}$ close to $\langle\boldsymbol{x}\rangle$, for example for x relatively contant, the ratio between equations (15) and equation (16) is the following.

$$\frac{\frac{d^2}{dt^2}\langle x\rangle\Big|_{x>x_{max}}}{\frac{d^2}{dt^2}\langle x\rangle\Big|_{x<x_{max}}} \cong -\frac{1}{12\pi}\frac{\rho_a}{\rho}\frac{1}{\alpha^2\sqrt{\beta}} \tag{19}$$

Where$\rho_a = \frac{m_a}{x_{max}^3}$,and $\rho$is given by equation (3), in the $\boldsymbol{x} > \boldsymbol{x_{max}}$ case. It has been used $\alpha = \frac{x}{x_{max}}$ in the $\boldsymbol{x} > \boldsymbol{xmax}$ case, and β=$\boldsymbol{xxmax}$ in the $\boldsymbol{x}$<$\boldsymbol{xmax}$ case .

Therefore the acceleration stays roughly constant and repulsive for $\boldsymbol{x} < \boldsymbol{x_a}$. Then itbecomes attractive and increases in a $\sqrt{\boldsymbol{x}}$ law for $\boldsymbol{x_a} < \boldsymbol{x} < \boldsymbol{x_{max}}$. This yields a solution for confinement. It becomes repulsive, increases very much, as $\boldsymbol{x}$, increasing, reaches $\boldsymbol{x_{max}}$.Then it decreases for $\boldsymbol{x}$ beyond $\boldsymbol{x_{max}}$ following a $\frac{1}{x^2}$ law.

The acceleration changes from repulsion to attraction and from attraction to a repulsion respectively when $\boldsymbol{x}$ crosses the$\boldsymbol{x_a}$ and$\boldsymbol{x_{max}}$ values. But an important result is that the acceleration reaches a very strong value for $\boldsymbol{x}$ just beyond $\boldsymbol{x_{max}}$.

This change of sign and this specific evolution beyond $\boldsymbol{x_{max}}$ have to be studied in front of experimental data. But the scale of those prediction is $\boldsymbol{x} > \boldsymbol{x_{max}} = \boldsymbol{1}\,\dot{\boldsymbol{A}}$. Therefore, those predictions might be difficult to invalidate or to validate.

8.3 Mass gap.

Once again, let's study the case of 2 particles pA and pB located in A and B, respectively. But now there is an added supposition which is that they are embedded in a complete vacuum. Equation (17)shows that the acceleration generated by pA does not depend of its mass any more.

But the distance, x, between pA and pB, is bound by a minimum. Indeed, equation (10) shows that the acceleration becomes repulsive for$\boldsymbol{x} < \boldsymbol{x_a}$. In the case of the srong interaction, equation (10) becomes the following.

$$\frac{d^2}{dt^2}\langle x\rangle \cong -\alpha\rho_2\frac{m_b}{M_b}\sqrt{x_{max}}x_a^{\frac{5}{2}} \tag{20}$$

It will be considered only an inertial referential frame which is locally attached to matter. In GMTET those particular frames are already playing a major role.$\langle\sqrt{\boldsymbol{x}}\rangle$ is driven by equation (20) for $\mathbf{x} < \boldsymbol{x_a}$ and by (17) for $\boldsymbol{x_a} < \boldsymbol{x} < \boldsymbol{x_{max}}$. Indeed, those 2 equations show a repulsion for low distances, and an attraction for greater distances.$\langle\sqrt{\boldsymbol{x}}\rangle$ does not depend of the mass of pA. It does not depend of the mass of pB if $\frac{m_b}{M_b}$ is supposed to be independent of $\frac{m_b}{M_b}$.It depends only on $\boldsymbol{x_a}$.Of course, $\boldsymbol{x_a}$ is bounded by Planck length:

$$\frac{d^2}{dt^2}\langle x\rangle > -\alpha\rho_2\frac{m_b}{M_b}\sqrt{x_{max}}\,l_p^{\frac{5}{2}} \qquad (21)$$

But even if this is a theoretical solution to the mass gap problem, nevertheless this value is probably far too low for a correct explanation of the physical mass gap problem:

Of course this final result is true whether the particles pA and pB are real or virtual.

This gives a simple explanation of the mass gap, appearing in vacuum.

But the prediction is that this minimum value in the RHS of equation (16) is not only valid in vacuum but in any cases.

9 Conclusion

GMTET can be seen as an extension of GR in which not only gravity, but each of the 4 forces are driven by space-time deformations and geodesics. It must be emphasized that this is an extension and not a contradicting version of GR, except for some small key points such as the composition of Lorentz transforms in the general 3D case, Pioneer anomaly, eclipses anomalies, added complications during the measurements of G, the variation of an equivalent G at large scale, and a different cosmological model.

PSMT is a simplified model designed for modelling this somewhat complicated behavior of GMTET, in the context of particle physics. In this interpretation given by PSMT, the Yang-Mills equations are slightly modified. This modification is very similar to the one which is done by SMT. It is based on an inner mechanism of GMTET, which is called the "second modification of Newton's law". Like with SMT, this mechanism can be stated in one sentence: <<it must be taken into account an added "elasticity" of space-time, which is inversely proportional to matter density at the location where the force is exerted>>.

Electromagnetism and weak interaction are not modified by PSMT.

But the strong interaction is modified by the mechanism described above. And this mechanism gives rise exactly to a solution for the "Yang-Mills" Millenium problem of the Mathematical Clay Institute. The issues of "mass gap" and "confinement" are given a unique and simple explanation. The explanation of the mass gap issue is based on the supposition that physics distances can't be weaker than the Planck length in any inertial referential frame which is attached to matter. Of course this statement is probably more a mathematical one than a physical one, due to the extremely low value of Planck Length.

This solution does not imply any regression in any other part of Yang-Mills theory itself. At first glance it does not imply any regression in particle physics.

This modification done by PSMT on Yang-Mills equations is only adding for the strong interaction a multiplying coefficient for the final force. This coefficient is varying below the Angstrom scale, and is roughly inversely proportional to matter density at the location where the force is exerted. But in this document this coefficient has been supposed as being a simple unquantified scalar. Another version of this document could work on a quantified coefficient.

The model has been tuned. In particular, equation (3) and the parameters of equation (2) in Table 1 has been fitted. But this prove that a solution can be suggested to confinement and mass gap problems only by tuning the extension mechanism which is done by GMTET over GR. In other words this document shows that such a solution can be found by tuning this GR extension, without modifying Yang-Mills theory itself.

Stated in one sentence, PSMT might yield a solution of the Yang-Mills Millenium problem without any regression elsewhere in any possible part of actual particle physics.

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