BRIDGING THE GAP BETWEEN CLASSICAL AND QUANTUM MECHANICS THROUGH GENERAL RELATIVITY

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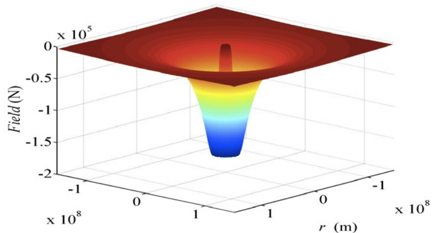
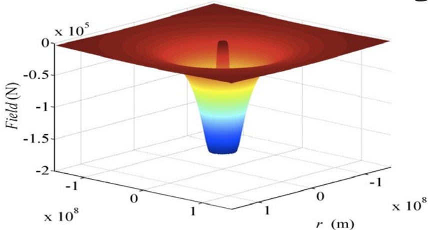


POLYTECHNIQUE MONTREAL

PHYSICS RESEARCH PROGRAM

Exploiting as much as possible the Bohr's correspondance principle to find the most can be done from a classical perspective to contribute to the development a Unified Theory of Physics using a paradigm governed by the central limit theorem and predicting the emergence of a modified Newton's law to provide new insights to bridge the gap between classical and quantum concepts and interpretations of the physical laws and their predictions, trying to build bridges between the different major trends currently under investigation and development.



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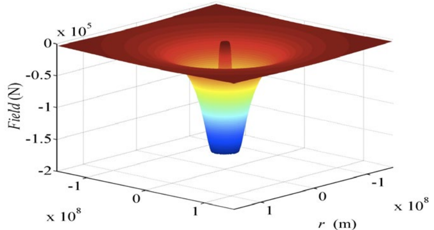
BIOMEDICAL RESEARCH PROGRAM

The central limit theorem approach has already been successful in my neuromotor control research program leading to the developpement of a Kinematic Theory of human movenents that can be applied in various fields like neurosciences, cybersecurity, pattern recognition artificial intelligence, robotics, etc…



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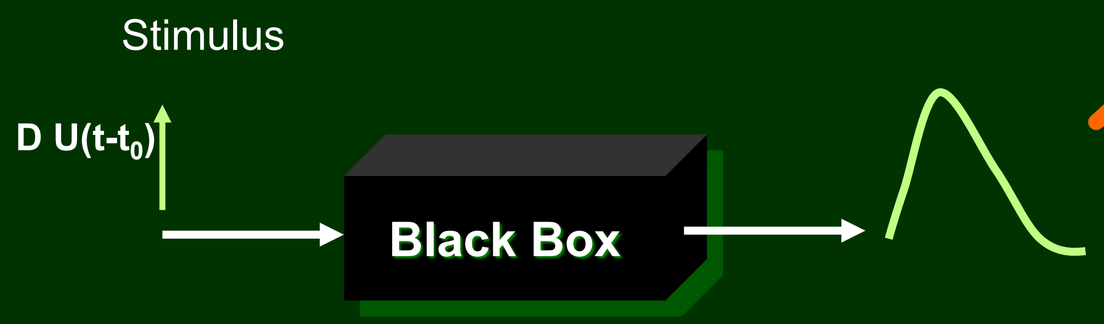
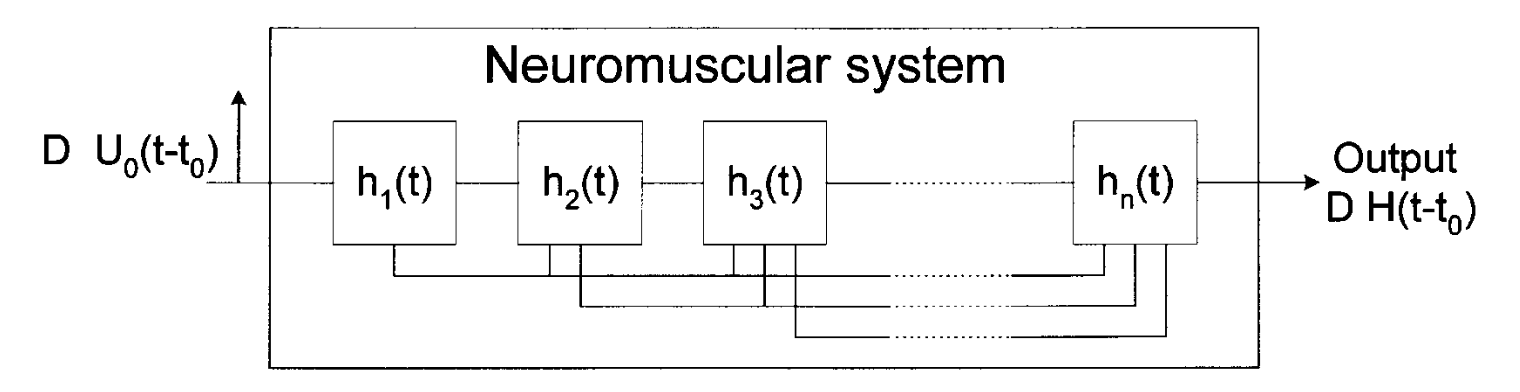
Modeling upper limb control



Command	NMS	Response
Impulse wheighted by a distance	*Convolution of an infinite number of coupled subsystems*	*Velocity profile*

- Mathematical proof based on the Central Limit Theorem
- Convergence of the NMS impulse response towards a lognormal profile



- Hypothesis

$$T_n = (1+\varepsilon_n)T_{n-1}$$

$$n \to \infty$$

$$H(t-t_0) \Rightarrow \Lambda(t; t_0, \mu, \sigma^2)$$

Lognormal Velocity Impulse Response

$$\left|\vec{v}(t,P)\right| = D\Lambda(t;t_o,\mu,\sigma)$$

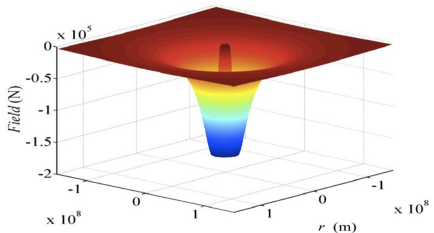
$$= \frac{D}{\sigma\sqrt{2\pi}(t-t_0)}\exp - \left[\frac{\left[\ln(t-t_0)-\mu\right]^2}{2\sigma^2}\right]$$

The basic primitive of human neuromotor control, its « hydrogen atom » from which a whole periodic table of movements can be described and analysed.

CONDITIONS FOR MODIFYING GRAVITY

If Newton’s laws have to be modified, the resulting modified gravity shall be an emergent, universal, scale independent paradigm directly embedded in Einstein’s General Relativity theory

(no adhoc plug-in)



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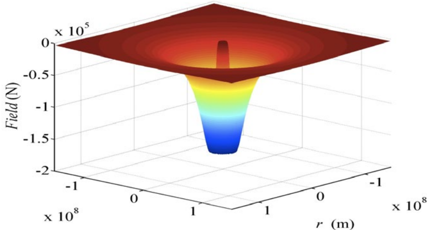
CONDUCTING THREADS

AN ANALOGY BETWEEN EINSTEIN'S GR LAW

$$G_{\mu\nu} = KT_{\mu\nu}$$

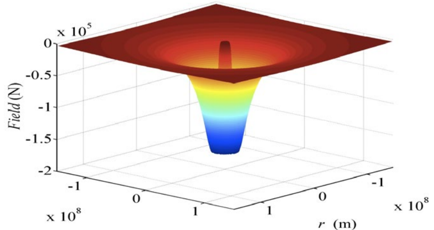
AND BAYES'S LAW

$$P(G_{\mu\nu} \,/\, T_{\mu\nu}) = P(T_{\mu\nu} \,/\, G_{\mu\nu}) \times \frac{P(G_{\mu\nu})}{P(T_{\mu\nu})}$$



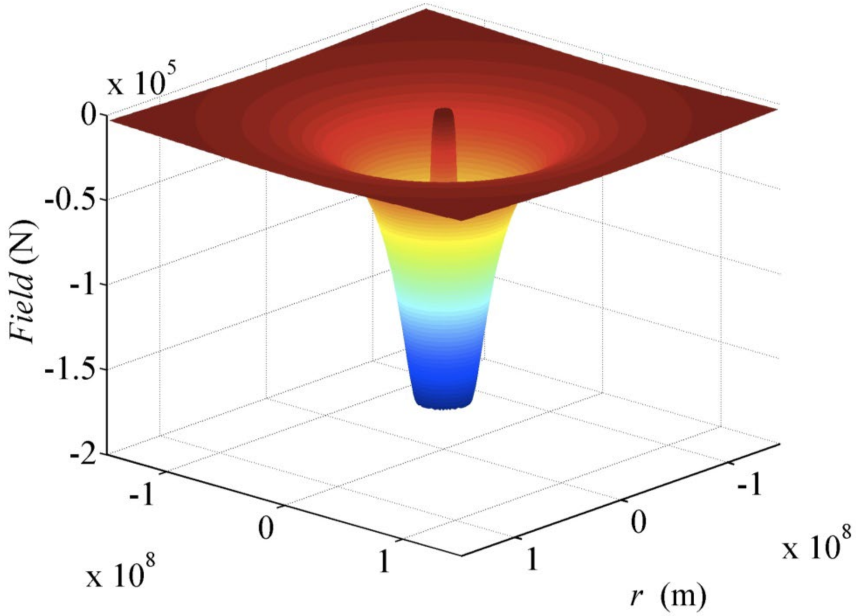
and using the Central Limit Therorem projected in a curved spacetime to incorporate the probability of presence of a given amount of energy momentum at a given spacetime curvature to predict the emergence of a Modified Newton's Law of gravitation

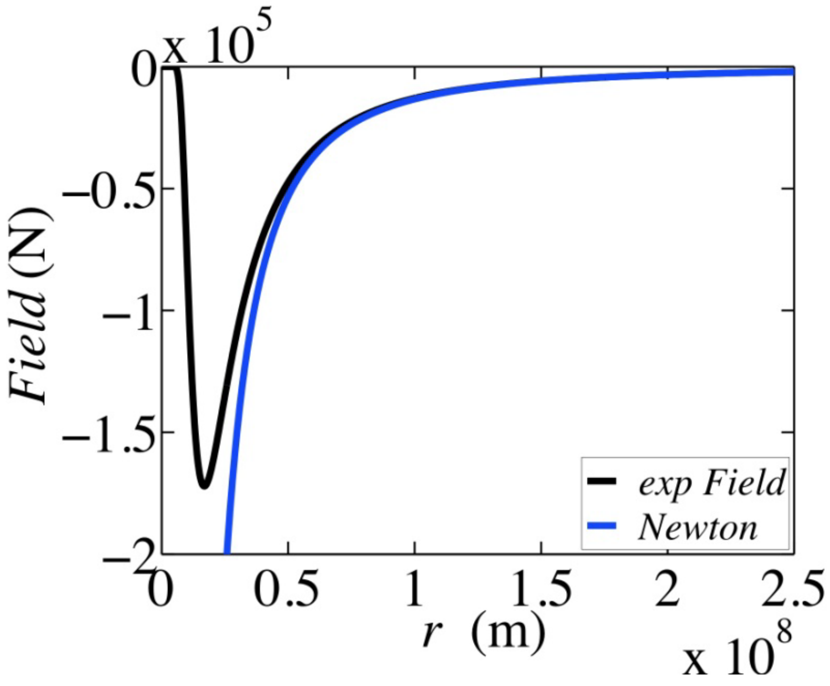
Plamondon, R., (2021) **What does the Central Limit Theorem Have to Say About General Relativity?**, in Quantum Theory and Symmetries, Proceedings of the 11th International Symposium, Montréal, Canada, , Paranjape, M.B., MacKenzzie, R, Thomova, Z., Winternitz, P., WitczKrempa, W., (EDS), Springer, CRM Series in Mathematical Physics, 503-511.

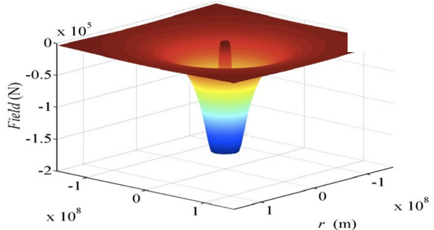


THE EMERGING FIELD

$$g(r) = -\left|\vec{\nabla}\Phi(r)\right| = -\frac{GM}{r^2}\exp\left(-\frac{\sigma^2}{2r^2}\right) \Rightarrow \simeq \left.\frac{GM}{r^2}\right|_{r\to\infty}$$







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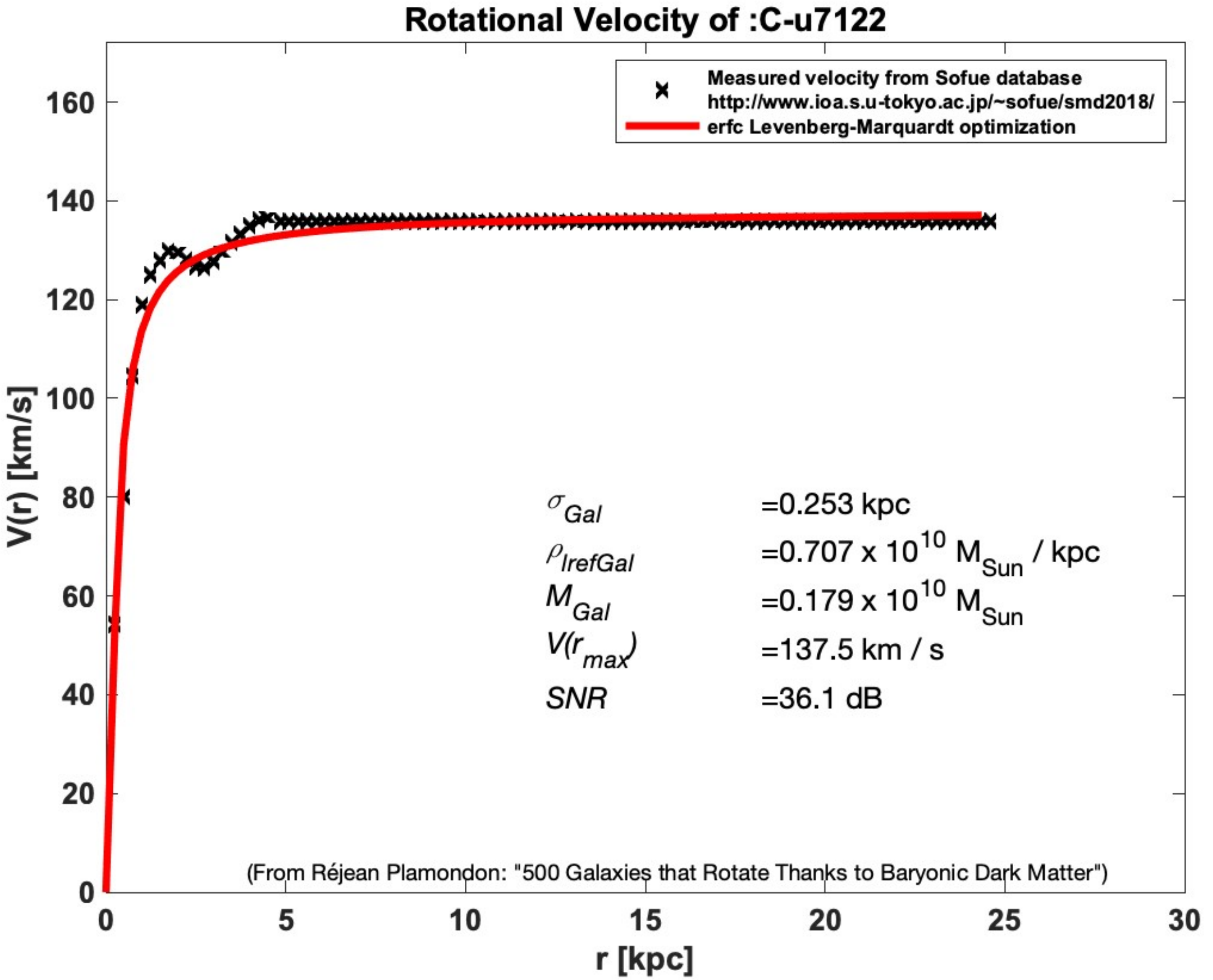
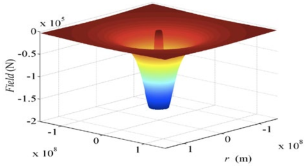
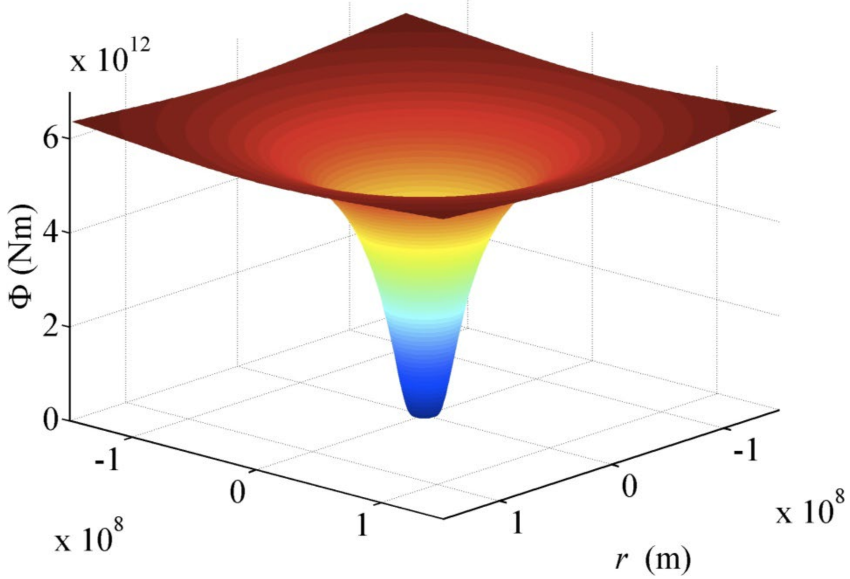
TYPICAL RESULTS >35dB

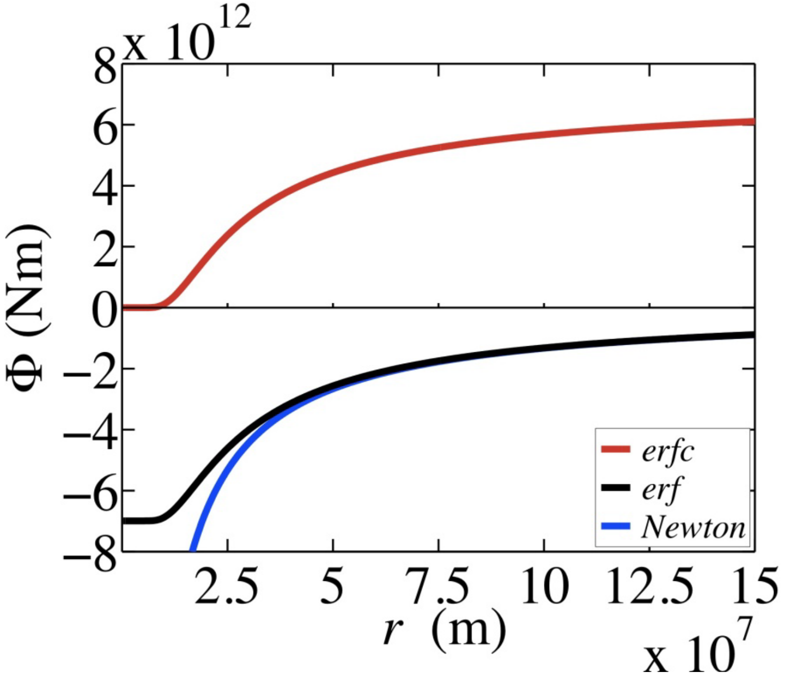


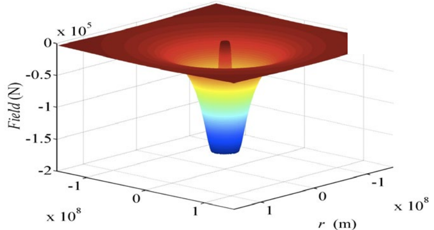


THE EMERGING POTENTIAL

$$\Phi_{erfc}(r) = GM\left(\frac{\sqrt{\pi}}{\sqrt{2}\sigma}\right)\color{red}{erfc}\left(\frac{\sigma}{\sqrt{2}r}\right)$$







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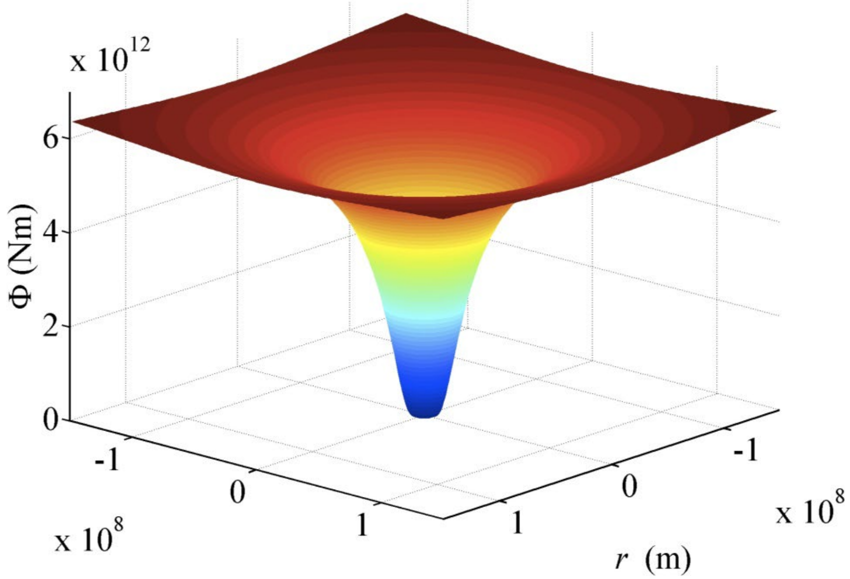
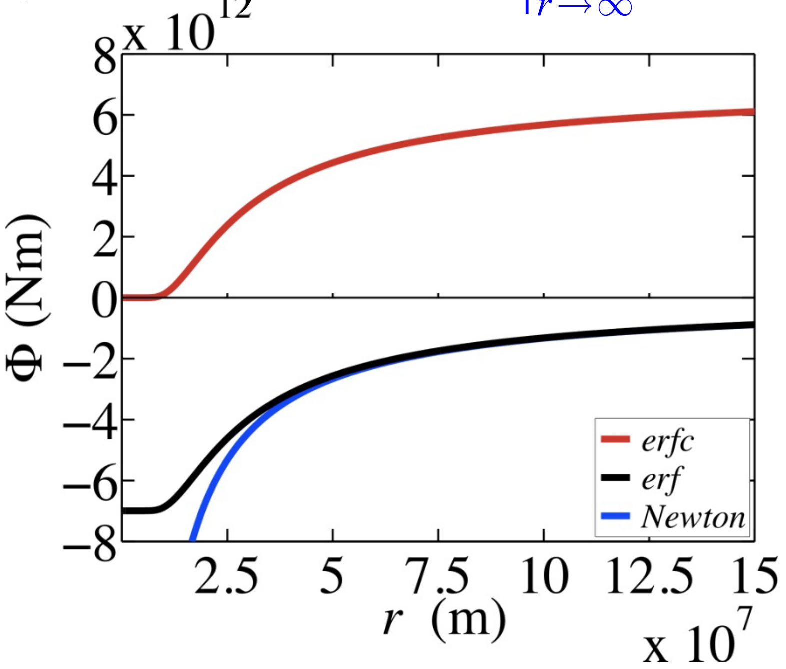
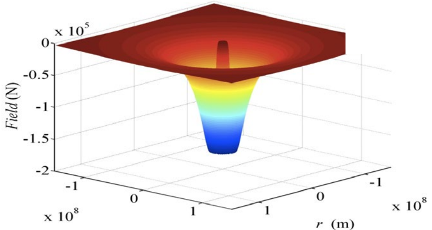
THE EMERGING POTENTIAL

$$\Phi_{erfc}(r) = GM\left(\frac{\sqrt{\pi}}{\sqrt{2}\sigma}\right) - GM\left(\frac{\sqrt{\pi}}{\sqrt{2}\sigma}\right) erf\left(\frac{\sigma}{\sqrt{2}r}\right)$$

$$\Phi_{erf}(r) = -GM\left(\frac{1}{r} - \frac{1}{6r^3} + \frac{1}{40r^5} - \dots\right) \cong -\frac{GM}{r}\Big|_{r\to\infty}$$





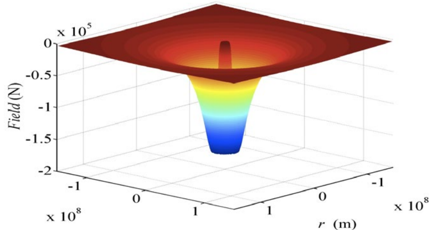


POLYTECHNIQUE MONTRÉAL

The *erfc* metric

$$ds^2 = \left[1 + \frac{\sqrt{2\pi}GM}{\sigma c_{th}^2} erfc\left(\frac{\sigma}{\sqrt{2}r}\right)\right] c_{th}^2 dt^2 - \left[1 + \frac{\sqrt{2\pi}GM}{\sigma c_{th}^2} erfc\left(\frac{\sigma}{\sqrt{2}r}\right)\right]^{-1} dr^2 - r^2 d\theta^2 - r^2 \sin^2\theta d\phi^2$$

This diagonal metric is a solution to the Einstein's field equations for a spherically symmetric system from r=0 to r=∞ . There is no null vacuum solution. Moreover, the relativistic tensors $R_{\mu\mu}$, $G_{\mu\mu}$, the Ricci and the Kretschmann scalars, all extend from $0 \le r \le \infty$ without any singularity.



Plamondon, R., (2018), **General Relativity: an erfc metric**, Results in Physics, 9, 456-462.

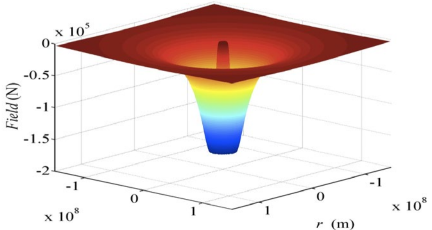
ERFC vs MINKOWSKI

Whatever the value of σ at $r = \infty$

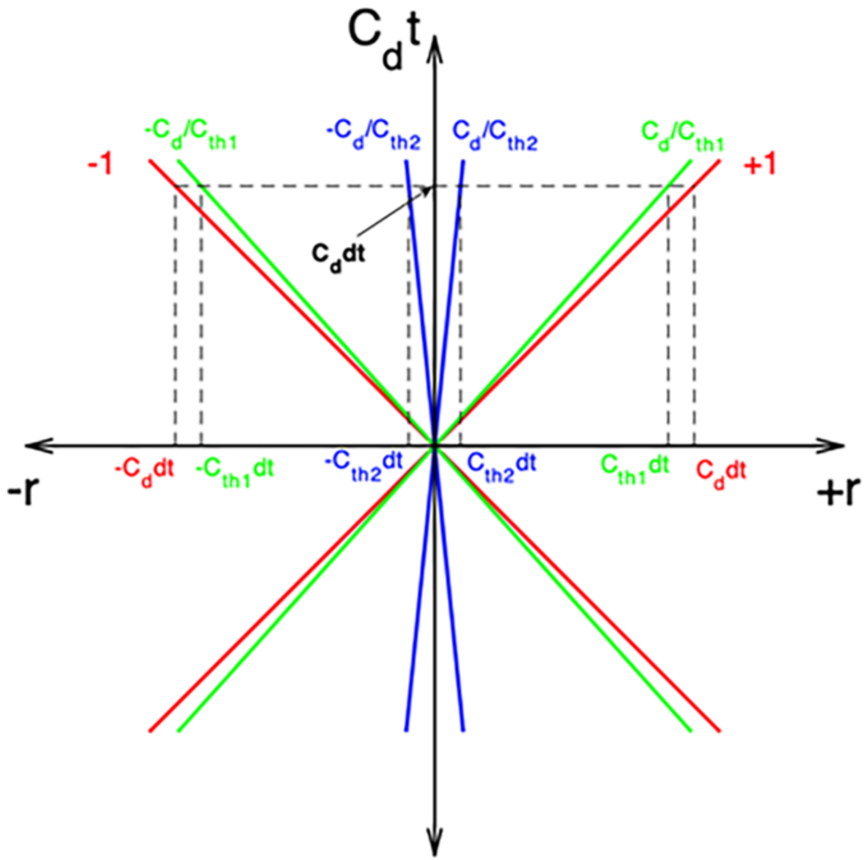
$$ds^2 = \left[1 + \frac{\sqrt{2\pi} GM}{\sigma c_{th}^2}\right] c_{th}^2 dt^2 - \left[1 + \frac{\sqrt{2\pi} GM}{\sigma c_{th}^2}\right]^{-1} dr^2 - r^2 d\theta^2 - r^2 \sin^2 \theta d\phi^2$$

Equivalent to a Minkowski metric if:

$$c_{th}^2 - c_{th} c_d + \frac{\sqrt{2\pi} GM}{\sigma} = 0$$



3.2.1The real solutions $\Delta > 0$

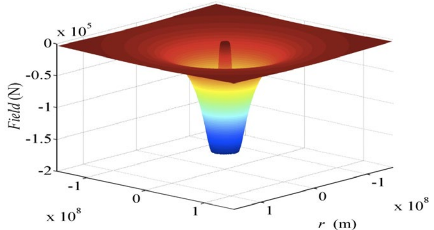


$$c_{th1,2} = \frac{c_d}{2} \pm \sqrt{\frac{c_d^2}{4} - \frac{\sqrt{2\pi}GM}{\sigma}}$$

$$c_{th1} + c_{th2} = c_d$$

$$c_{th1} c_{th2} = \frac{\sqrt{2\pi}GM}{\sigma}$$

$$ds_d^2 = ds_{th1}^2 + ds_{th2}^2$$



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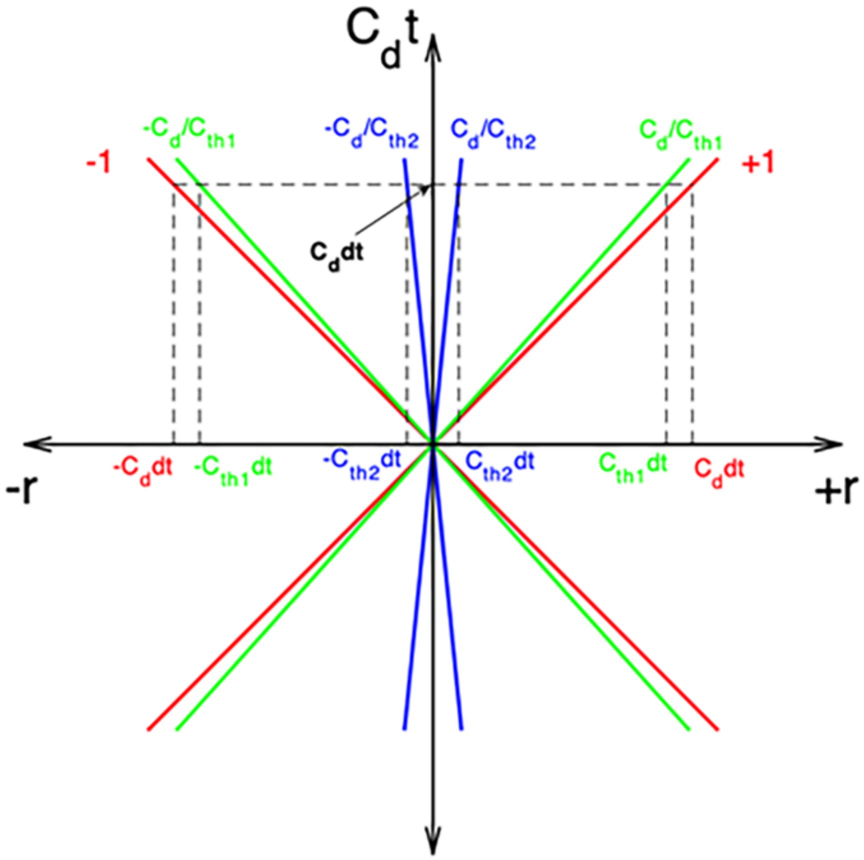
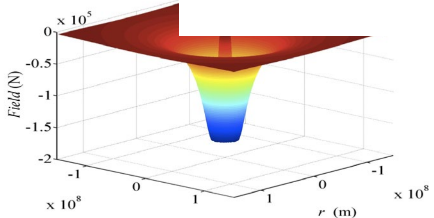


where the c_{th1} component can be seen as the speed of light with respect to a fixed space-time and the c_{th2} component as a spacetime expansion.



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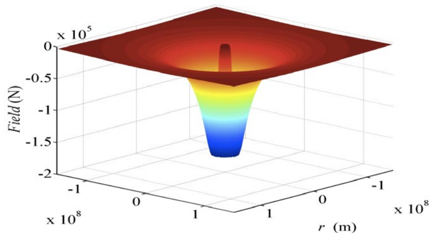
The Doppler Hubble constant

$$V_{\text{gal}} = H_{0\,Doppler} D_{\text{Mpc}}$$

$$\text{where } H_{0\,Doppler} = \frac{2c_{th_2}}{3.26\text{Mpc}} = 74.42(.02)\left(\text{km/s} \cdot \text{Mpc}\right)$$



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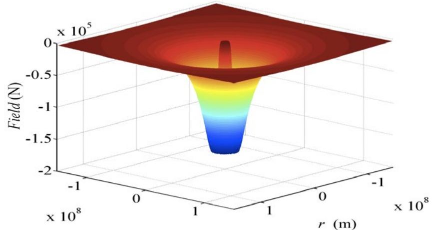
A Cosmological model

Hypothesis: the *erfc* potential is a source of baryonic matter energy density, describing the total energy available in the Universe:

$$\Omega_m + \Omega_r + \Omega_k = erfc\left(\frac{\sigma_U}{\sqrt{2r}}\right) = 1 - erf\left(\frac{\sigma_U}{\sqrt{2r}}\right)$$

where Ω_m , Ω_r , Ω_k are the dimensionless densities, with $\Omega_m + \Omega_r$ representing the total baryonic energy available in the universe and Ω_k the curvature density parameter.



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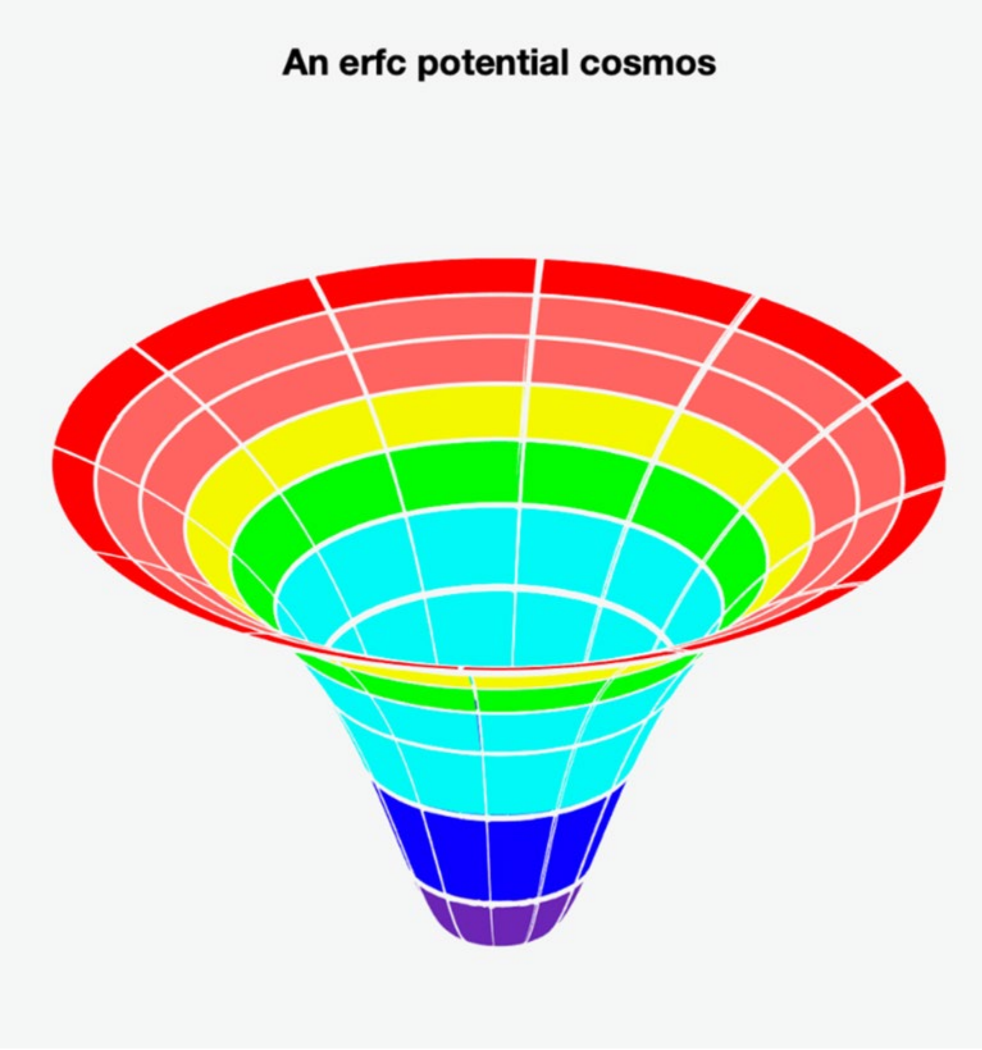
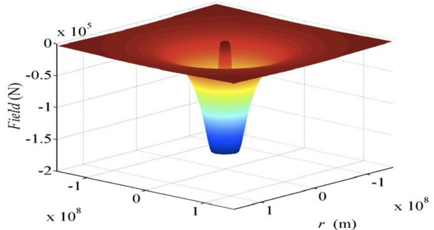
Evolution of the *erfc* universe





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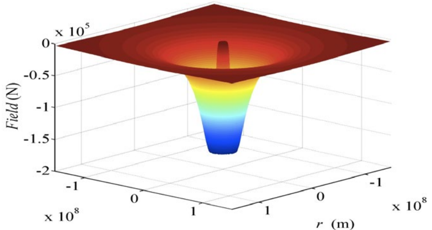
The Doppler vs CMB Hubble constant

$$H_{0\mathrm{Doppler}}\left(0.6827\right)^{1/4} = H_{0\mathrm{CMB}}$$

$$74.42\,\frac{\mathrm{km/s}}{\mathrm{Mpc}}\times 0.909 = 67.64\,\frac{\mathrm{km/s}}{\mathrm{Mpc}}$$

$$\Lambda_{\mathrm{CDM}} = 1.0951\times 10^{-52}\,\mathrm{m}^{-2}$$



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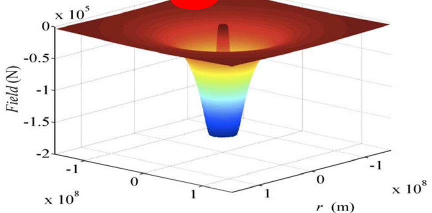
BIG MYSTERIES SURVEY

Among the ten foundational and controversial topics in contemporary physics, as reported in the large-scale survey conducted through the American Physical Society's *Physics Magazine* in 2024-2025, stands the Quantum gravity problem, the unification of quantum mechanics with gravity.



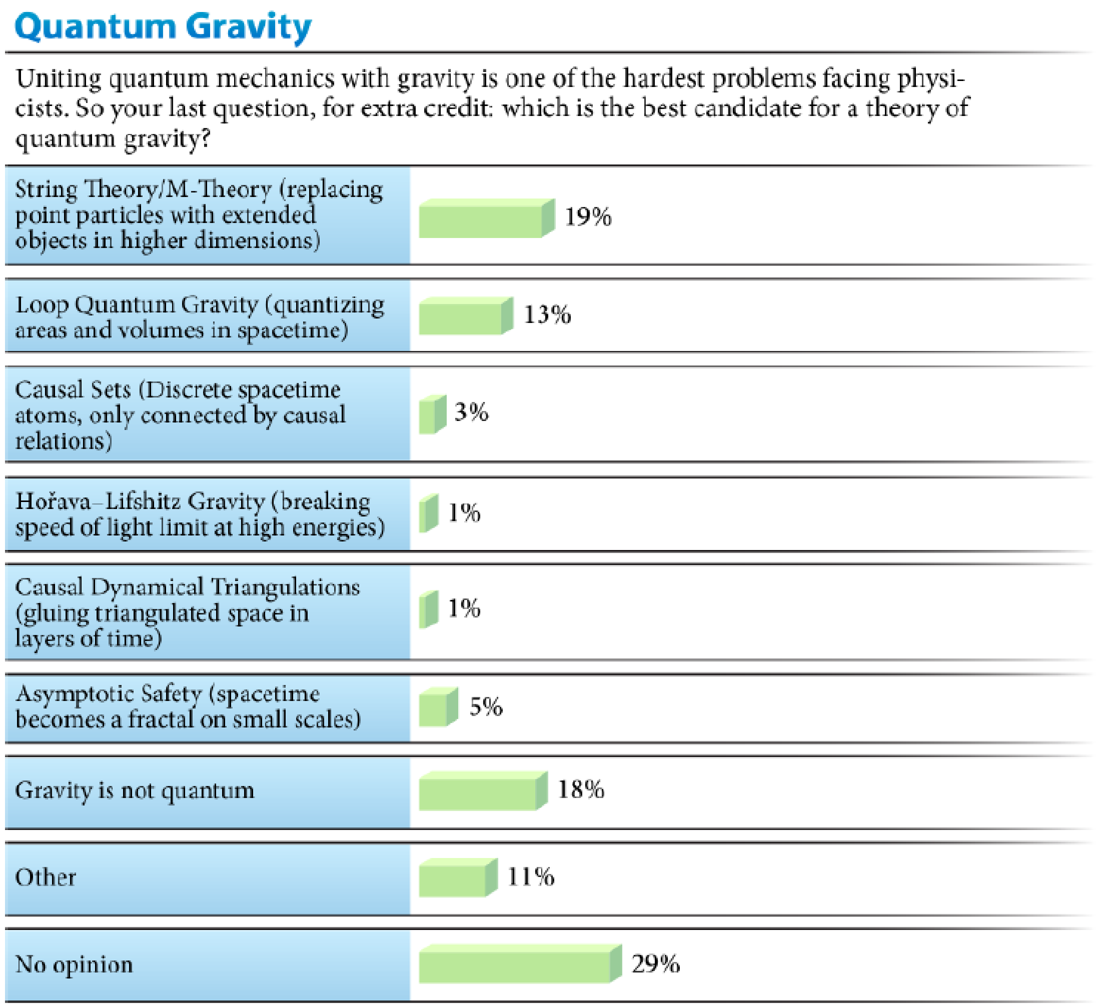


FIG. 11. Big Mysteries Survey (1,675 respondents): Which candidate is most likely to provide a theory of quantum gravity?

Which is the best candidate for a theory of quantum gravity?

ROAD MAP

1-The Unifying Nature of the *erfc* Metrics

3.1 The vacuum solution

3.2 The far distant gravitational solution

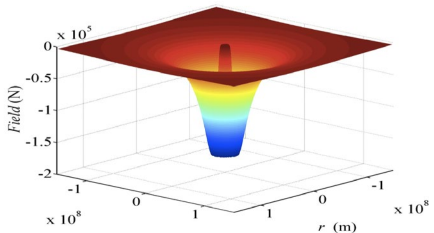
3.2.1The real solutions

3.2.2 The null solution

3.2.3 The complex solutions

2-Emergence of the Wave Particle Duality and a Static Schrodinger Equation

3- Concluding remarks: the hidden variable σ



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ROAD MAP

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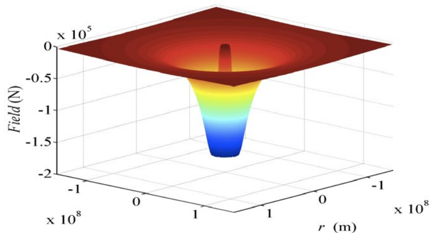

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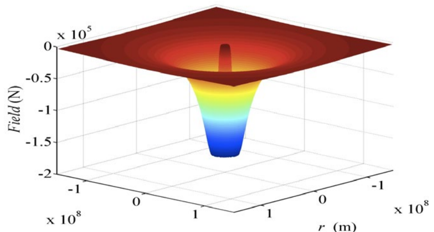
ERFC vs MINKOWSKI

Whatever the value of σ at $r = \infty$

$$ds^2 = \left[1 + \frac{\sqrt{2\pi}GM}{\sigma c_{th}^2}\right] c_{th}^2 dt^2 - \left[1 + \frac{\sqrt{2\pi}GM}{\sigma c_{th}^2}\right]^{-1} dr^2 - r^2 d\theta^2 - r^2 \sin^2\theta d\phi^2$$

Equivalent to a Minkowski metric if:

$$c_{th}^2 - c_{th}c_d + \frac{\sqrt{2\pi}GM}{\sigma} = 0$$



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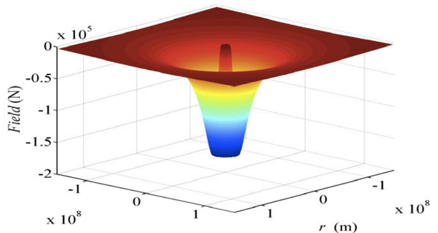
The complex solution $\Delta < 0$

$$\Delta = \frac{c_d^2}{4} - \frac{\sqrt{2\pi GM}}{\sigma} < 0$$

$$c_{th1,2} = \frac{c_d}{2} \pm i\sqrt{\frac{\sqrt{2\pi GM}}{\sigma} - \frac{c_d^2}{4}}$$



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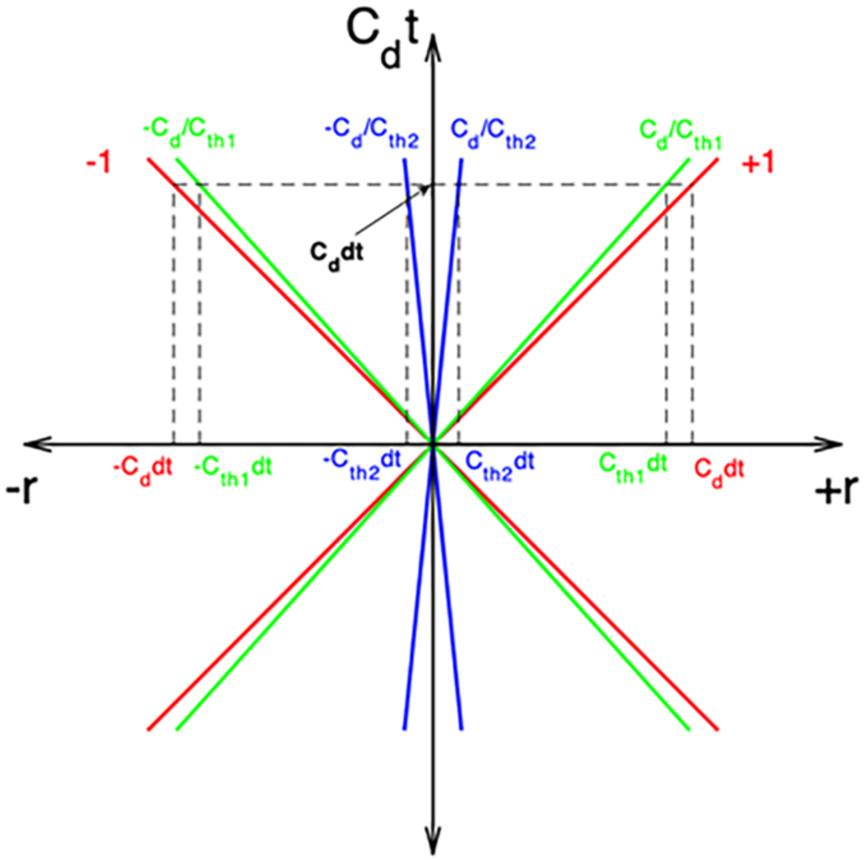
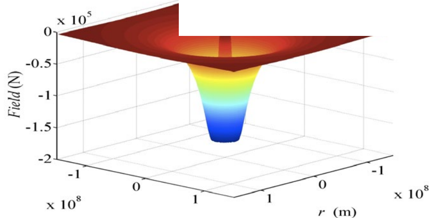
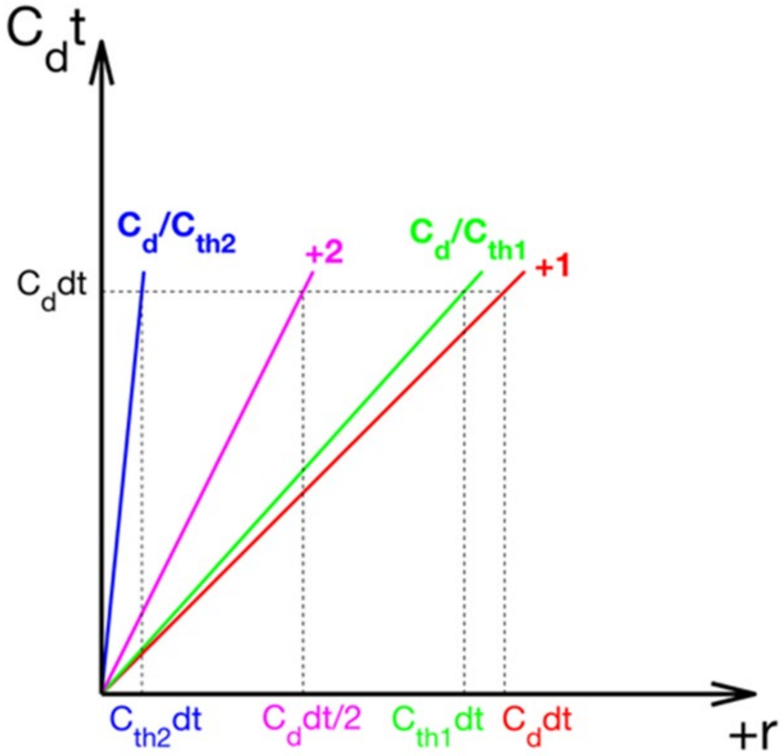


where the c_{th1} component can be seen as the speed of light with respect to a fixed space-time and the c_{th2} component as a spacetime expansion.

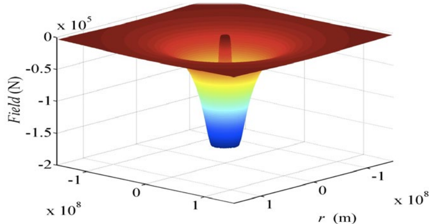


3.2.2 The null solution $\Delta = 0$



$$\frac{\sqrt{2\pi}GM}{\sigma} = \frac{c_d^2}{4} \Rightarrow \sigma = \frac{4\sqrt{2\pi}GM}{c_d^2} = 4\sqrt{2\pi}R_{schwarchild}$$

$$c_{th_1} = c_{th_2} = \frac{c_d}{2}$$



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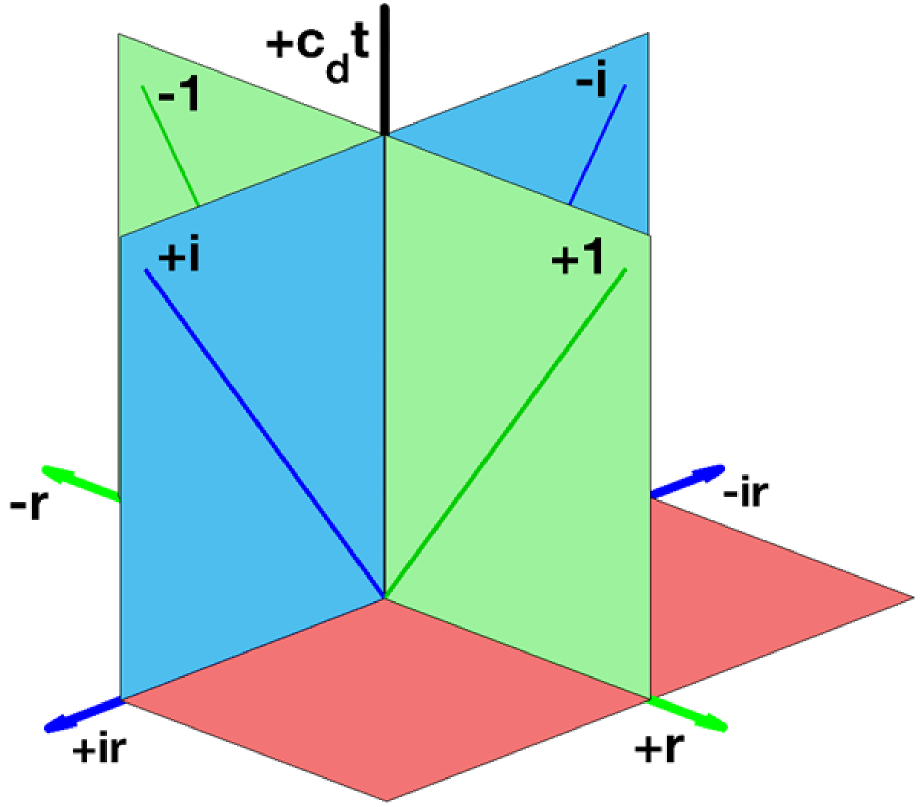
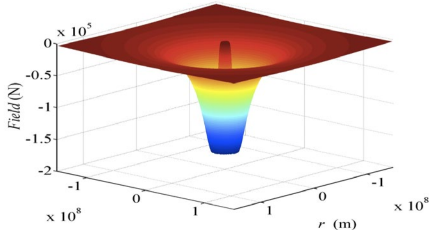
Emergence of a complex spacetime

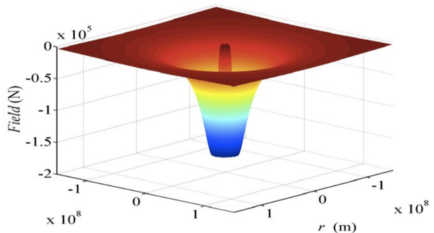




POLYTECHNIQUE MONTRÉAL

One key feature of the *erfc* potential

$$\frac{GM}{c_d^2\sigma} = \frac{G}{c_d^2}\rho_{lref} = \frac{\rho_{lref}}{\rho_{lP}}$$



POLYTECHNIQUE MONTRÉAL

ROAD MAP

1-Incorporation Probabilities in General Relativity

2-Emergence of a Modified Newton's Law

3-The Unifying Nature of the *erfc* Metrics

- 3.1 The vacuum solution
- 3.2 The far distant gravitational solution
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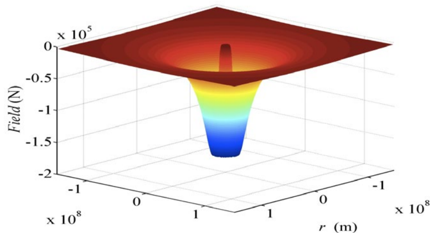
4-Emergence of the Wave Particle Duality and the Static Schrodinger Equation

5- Concluding remarks: the hidden variable σ



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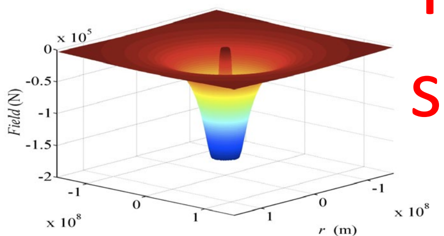
The complex solution $\quad \Delta < 0$

An interresting special case:

$$\rho_{lP} = \frac{c_d^2}{G} = \frac{\sqrt{2\pi}M}{\sigma} \Rightarrow \frac{\sqrt{2\pi}GM}{\sigma} = c_d^2$$

$$c_{th1}^2 + \frac{\sqrt{2\pi}GM}{\sigma} = c_d^2\left[\frac{1}{2} + \frac{i\sqrt{3}}{2}\right]$$

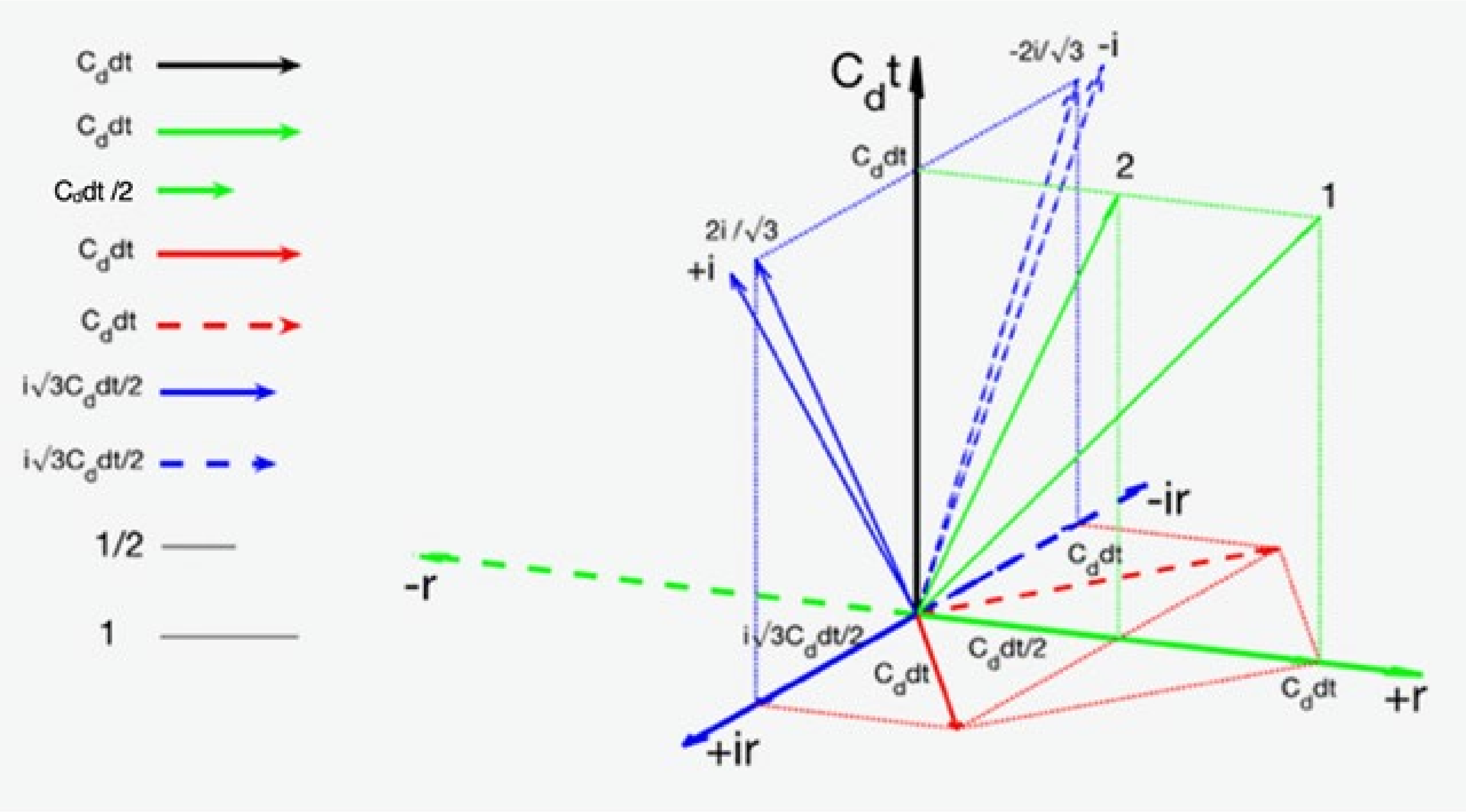
$$c_{th2}^2 + \frac{\sqrt{2\pi}GM}{\sigma} = c_d^2\left[\frac{1}{2} - \frac{i\sqrt{3}}{2}\right]$$

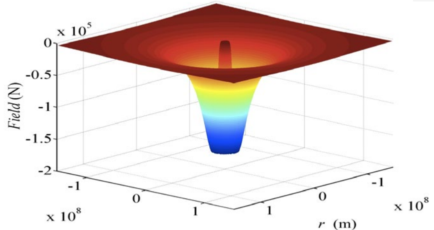


Two complex conjugate versions of a photon coexist in this spacetime representation.

POLYTECHNIQUE MONTRÉAL

The Complex Solution $\Delta < 0$





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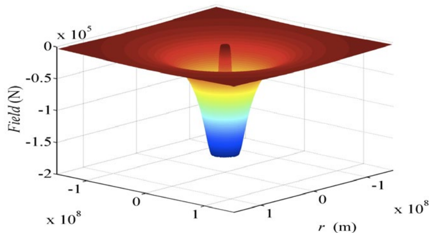
The complex solution $\Delta < 0$

The photon velocity is always limited to c_d in the real, the virtual and the complex planes but it has two virtual complex conjugate components that both cancel once projected in the real spacetime. In accordance with the superposition principle the two particle components exist in both states simultaneously.



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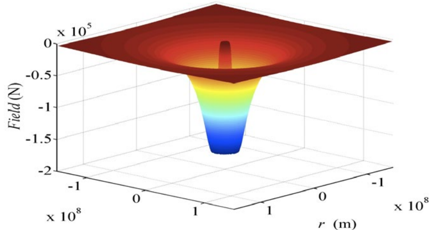
The Young experiment

Looking at the red instantaneity plane, one can see that if there is no measurement, the twin photons live in the complex spacetime. Summing up the two components make the two virtual components to collapse instantaneously along the real axis. This representation provides a simple explanation to the Young two slit experiment. If there is no measurement the twin complex photons can go virtually through both slits, and they collapse as a single real particle in the real interference plane.



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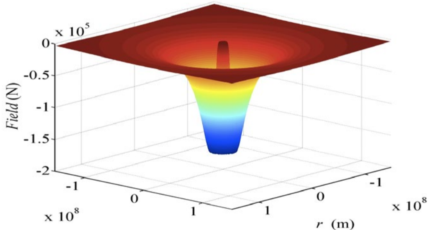
A static Schrodinger equation for a test mass

$$\frac{\sqrt{2\pi}GMm_{test}}{\sigma}\left[\frac{1}{2}+\frac{i}{c_d}\sqrt{\frac{\sqrt{2\pi}GM}{\sigma}-\frac{c_d^2}{4}}\right]=m_{test}c_d^2\left[\frac{1}{2}+\frac{i}{c_d}\sqrt{\frac{\sqrt{2\pi}GM}{\sigma}-\frac{c_d^2}{4}}\right]$$

$$\frac{\sqrt{2\pi}GMm_{test}}{\sigma}\left[\frac{1}{2}-\frac{i}{c_d}\sqrt{\frac{\sqrt{2\pi}GM}{\sigma}-\frac{c_d^2}{4}}\right]=m_{test}c_d^2\left[\frac{1}{2}-\frac{i}{c_d}\sqrt{\frac{\sqrt{2\pi}GM}{\sigma}-\frac{c_d^2}{4}}\right]$$



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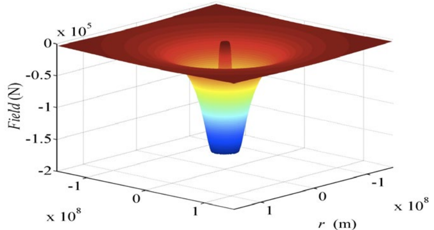
A static “Schrodinger-like” equation for a test mass

$$H_1\psi_+ = E_1\psi_+$$

$$H_2\psi_- = E_2\psi_-$$

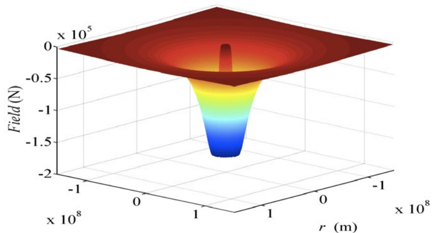
which link the classical Hamiltonian of a test particle at rest in a constant gravitational potential to its total mass energy weighted by complex functions that can be analogically interpreted as the wave functions associated to a test mass in the virtual plane and that obeys a static Schrodinger-like equation.



Definition of a measurement $\Delta < 0$

Making a measurement, that is summing up these two equations , provoques the collapse of the virtual wave function:

$$H_1 + H_2 = H_{tot} = \frac{\sqrt{2\pi}GMm_{test}}{\sigma} = E_1 + E_2 = E_{tot} = m_{test}c_d^2$$



ROAD MAP

1-Incorporation Probabilities in General Relativity

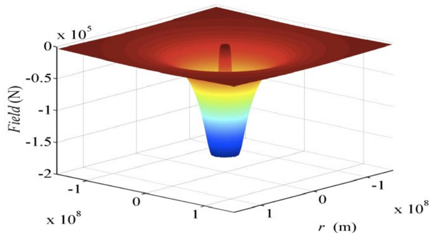
2-Emergence of a Modified Newton’s Law

3-The Unifying Nature of the *erfc* Metrics

- 3.1 The vacuum solution
- 3.2 The far distant gravitational solution
  - 3.2.1The real solutions
  - 3.2.2 The null solution
  - 3.2.3 The complex solutions

4-Emergence of the Wave Particle Duality and the Static Schrodinger Equation

5- Concluding remarks: the hidden variable σ



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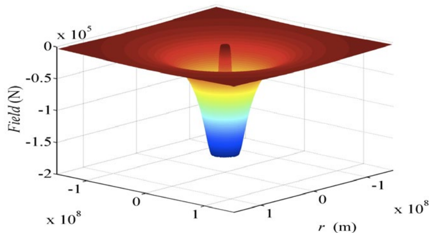
TAKE HOME MESSAGE #1

A modified Newton's Law
automatically emerges
from General Relativity
when the probability of presence
of the energy-momentum density
is taken into account into Einstein's equation.



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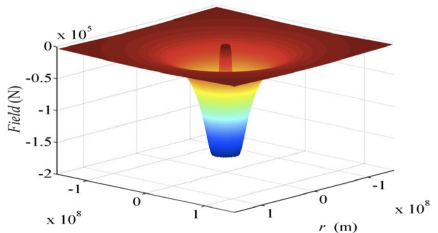
TAKE HOME MESSAGE #2

This modified Newton's Law

$$g(r) = -\frac{GM}{r^2}\exp\left(-\frac{\sigma^2}{2r^2}\right)$$

is characterized by an emergent Lorentz's scalar σ that defines the intrinsic reference proper length of any massive system



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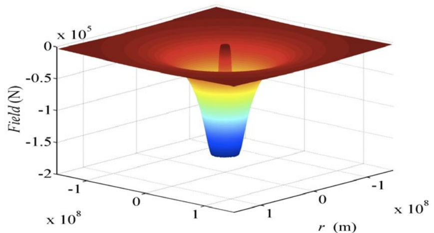
TAKE HOME MESSAGE #3

The emergent modified Newton's field relies on an erfc potential

$$\Phi_{erfc}(r) = {\color{red} GM\left(\frac{\sqrt{\pi}}{\sqrt{2}\sigma}\right)} - GM\left(\frac{\sqrt{\pi}}{\sqrt{2}\sigma}\right) erf\left(\frac{\sigma}{\sqrt{2}r}\right)$$

that incorporates

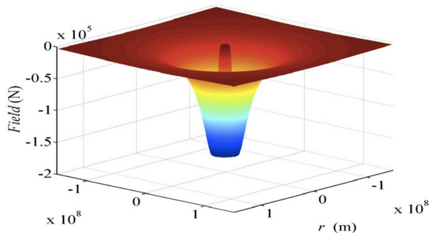
a constant reference component



POLYTECHNIQUE MONTREAL

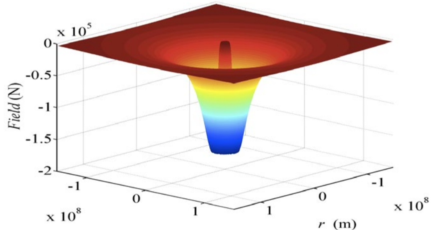
One key feature of the *erfc* potential

One key feature of this model is that it relies on the existence of an intrinsic emergent physical constant σ, a star-specific proper length that scales all its surroundings and plays the role of a hidden variable to link classical and quantum mechanics concepts.



One key feature of the *erfc* potential

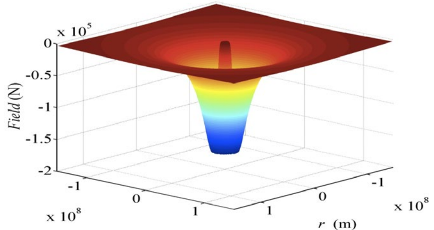
In the present complex solution context, σ can be seen as a measurable local hidden variable that allows to integrate general relativity, nuclear physics and quantum mechanics.



WORK IN PROGRESS

In the present complex solution context, σ can be seen as a measurable local hidden variable that allows to integrated general relativity, nuclear physics and quantum mechanics.

Once the Hamiltonian and energy functions will be replaced by their corresponding operators it will raise numerous questions, provide numerous solutions to which experts in the corresponding fields could provide new interpretations.



WORK in PROGRESS

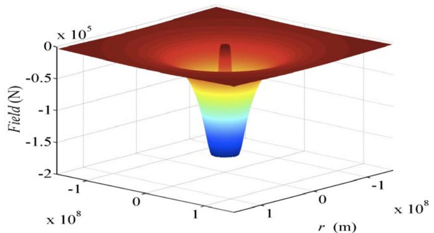
No quantification yet (Theory Canada and CAP 2027)

Links with the standard model?

Too many intuitive educated guesses?

Mostly provide postdictions not predictions…

Numerous analogies with current big mysteries



WORK in PROGRESS

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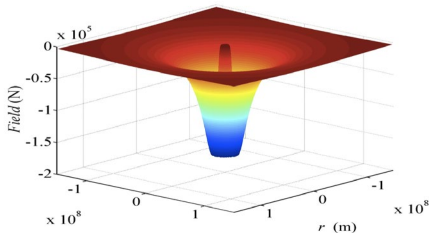
Challenge: unifying without defying but simplicity must prevail.

“Pluralitas non est ponenda sine necessitate”(Occam Rasor)



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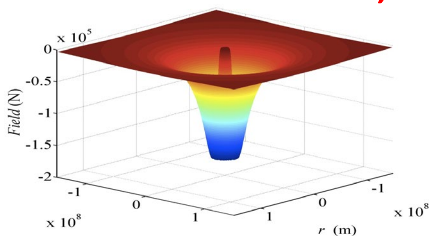

BRIDGING THE GAP BETWEEN CLASSICAL AND QUANTUM MECHANICS THROUGH GENERAL RELATIVITY

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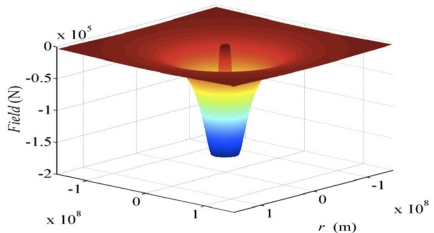
QUESTIONS?



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