Dark Matter and Dark Energy as Quantum Entities

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Overview

1. I shall start by describing a newly proposed relativity termed Information Relativity theory.

2. I shall point out the main features of the theory.

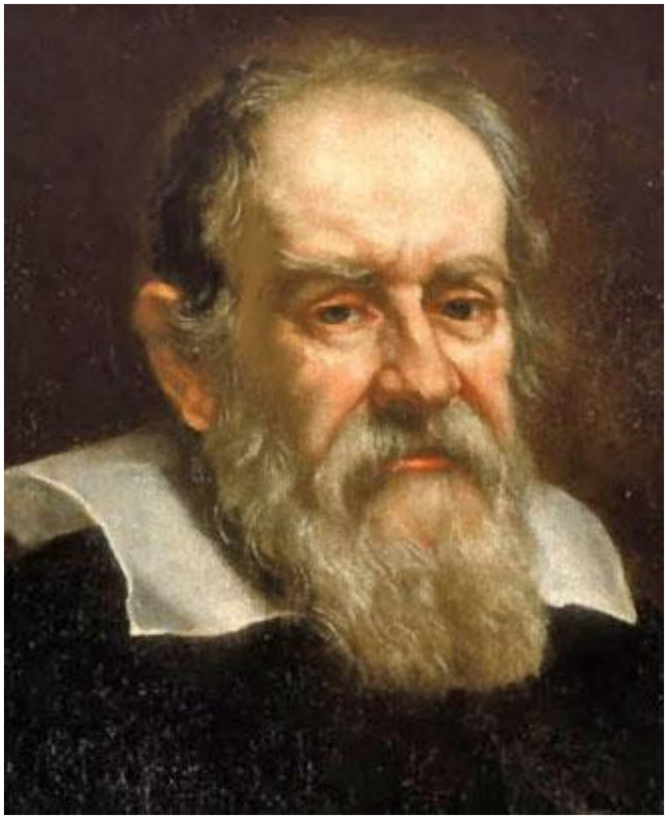
3. In particular, I shall show that the theory gives rise to a matter-wave duality model, similar to the realistic de Broglie-Bohm model.

4. Then I shall give a glimpse of the theory's application to quantum phenomena.

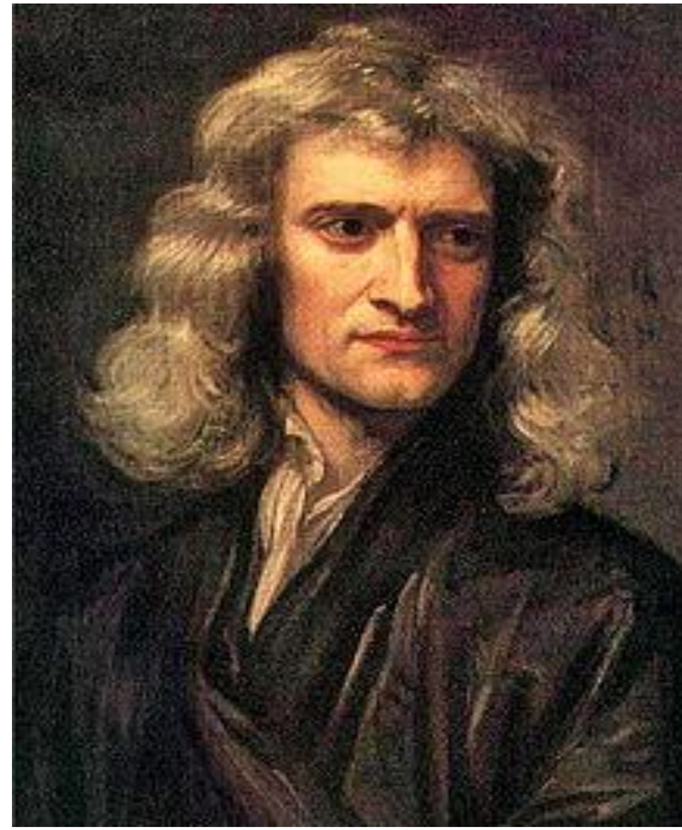
5. Following, I shall outlay a simple quantum cosmological model, and suggest a simple, yet plausible interpretation of dark matter and dark energy.

6. I shall conclude with some remarks.

Information Relativity Theory (IR)



Galileo Galilei
1564 - 1642

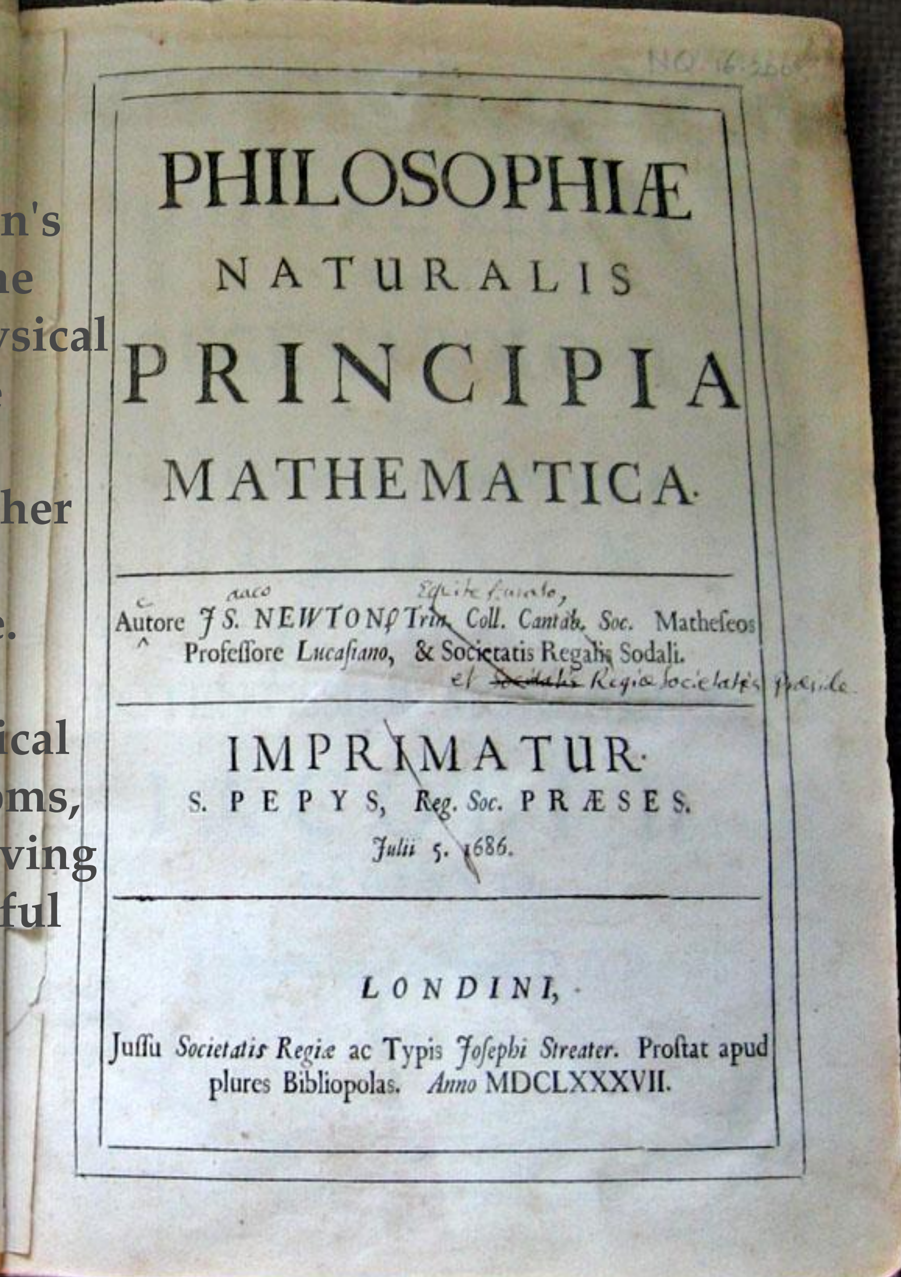


Sir Isaac Newton
1642 – 1726

What is IR?

IR consists of relativizing Newton's physics by accounting for the time travel of information about a physical measurement, from the reference frame at which the measurement was taken, to an observer in another reference frame, in a state of motion, relative to the first frame.

This minor modification of classical physics, without adding any axioms, turns out to be sufficient for deriving a simple and aesthetically beautiful theory of everything.


PHILOSOPHIÆ
NATURALIS
PRINCIPIA
MATHEMATICA.

Autore J S. NEWTON, Trin. Coll. Cantab. Soc. Matheseos Professore Lucasiano, & Societatis Regalis Sodali.

IMPRIMATUR.
S. PEPYS, Reg. Soc. PRÆSES.
Julii 5. 1686.

LONDINI,

Jussu Societatis Regiæ ac Typis Josephi Streater. Prostat apud plures Bibliopolas. Anno MDCLXXXVII.

IR is:

1. **Axiom-free**

2. **Simple and Beautiful**

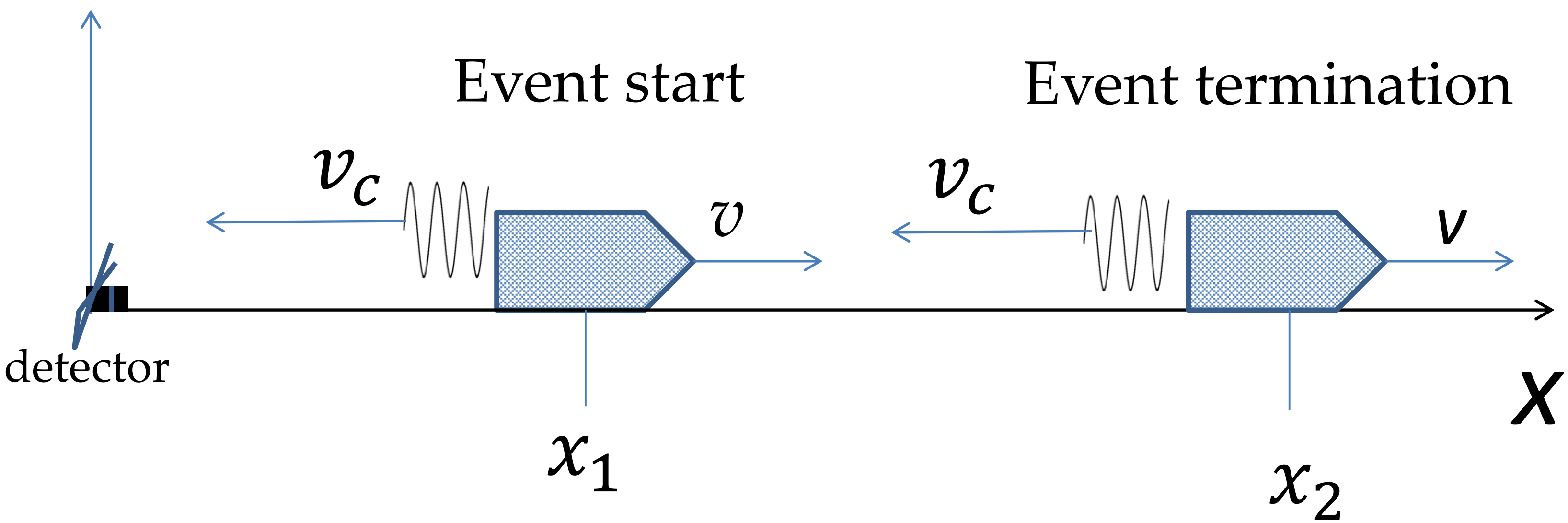
3. **Expressed only in terms of physical observables**

4. **Applies to all moving bodies, from small particles to galaxies, and other massive cosmological structures**

5. **Does not require clocks synchronization**

6. **Preserves continuity with Galilei-Newton's physics**

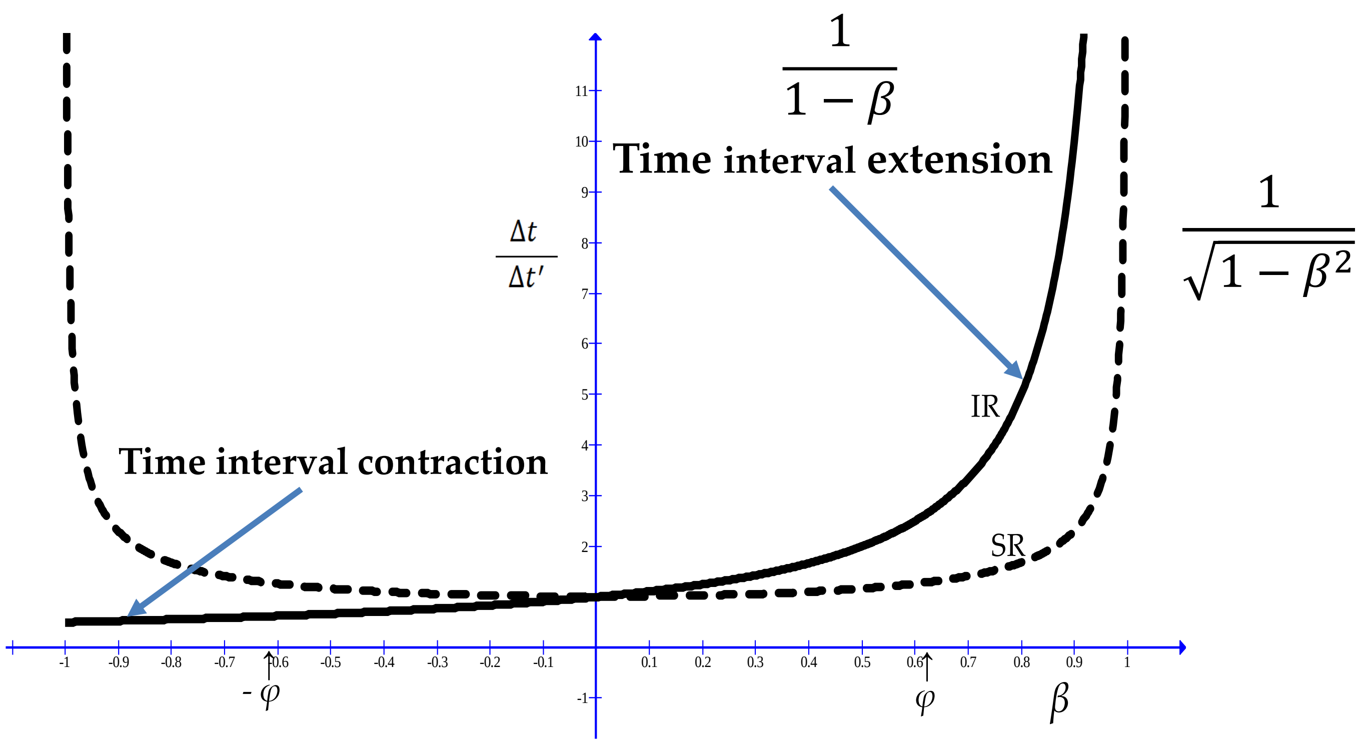
Relativizing Newton: Information Relativity Theory



The information carrier can be anything that moves with uniform velocity, provided that $v_c > v$.

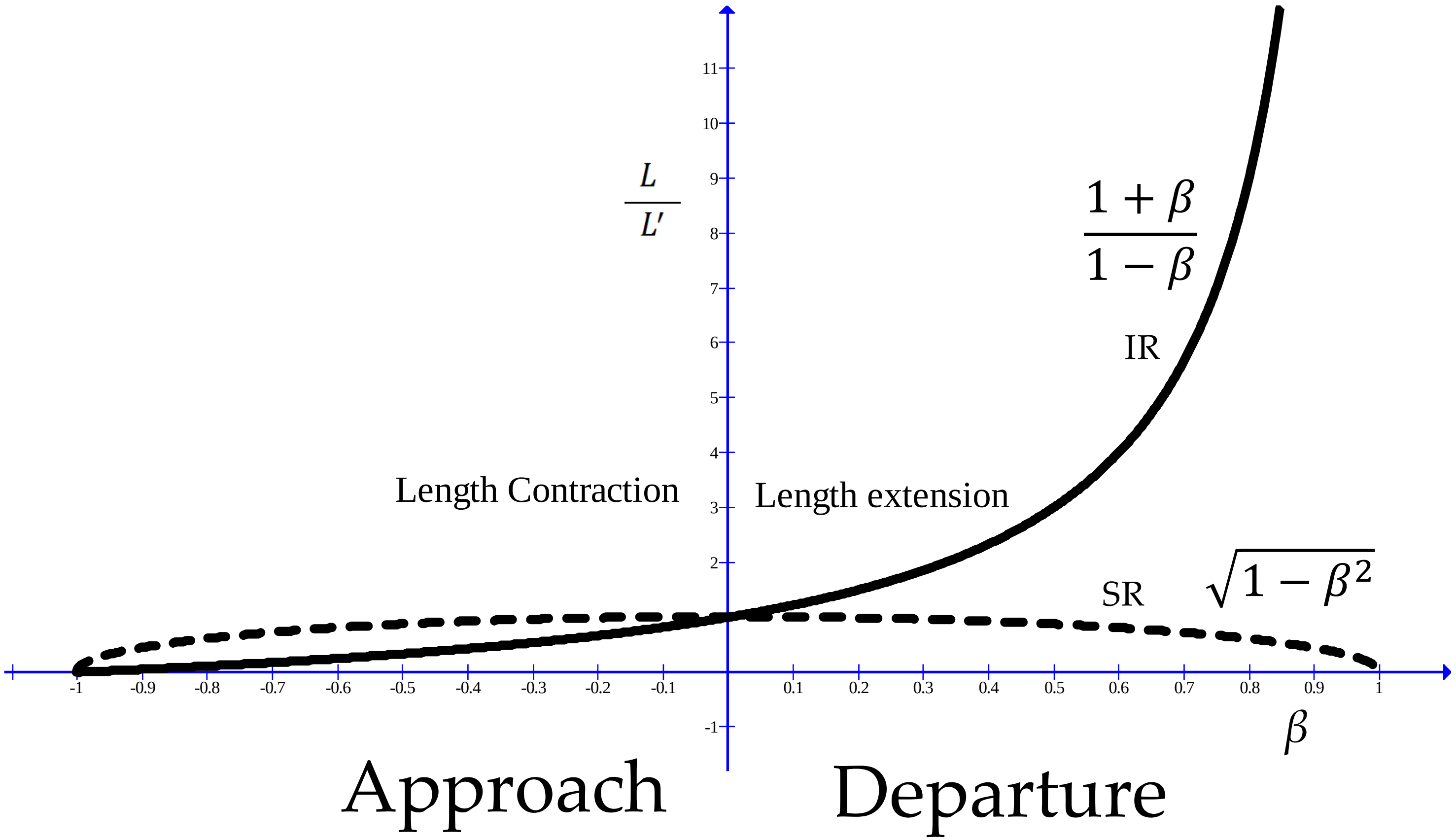
Electromagnetic, acoustic, seismic, ….

Time interval transformation

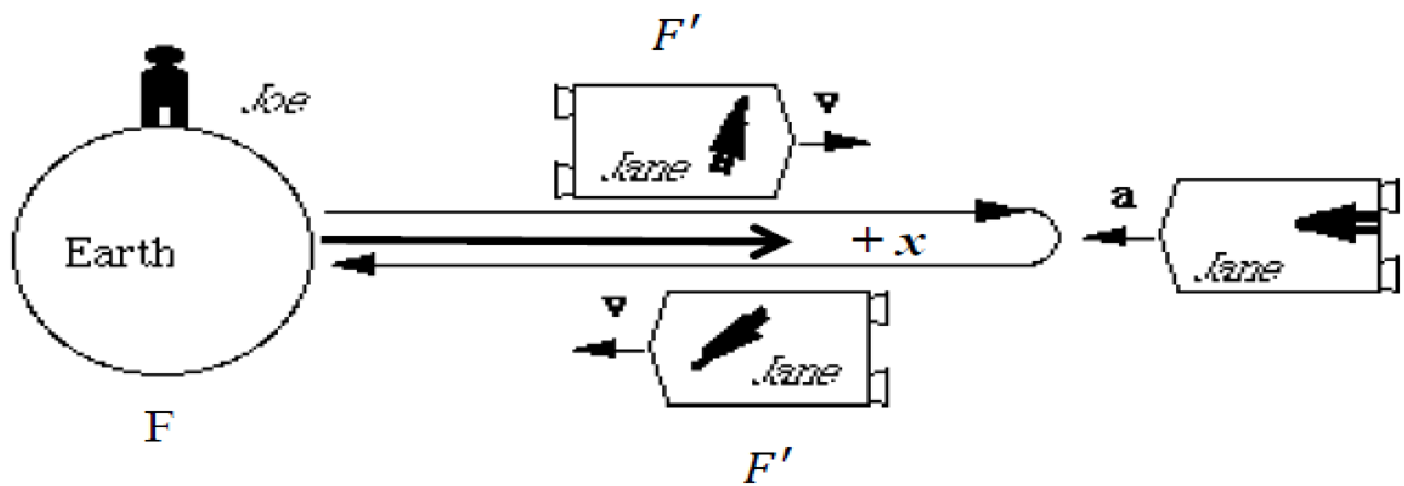


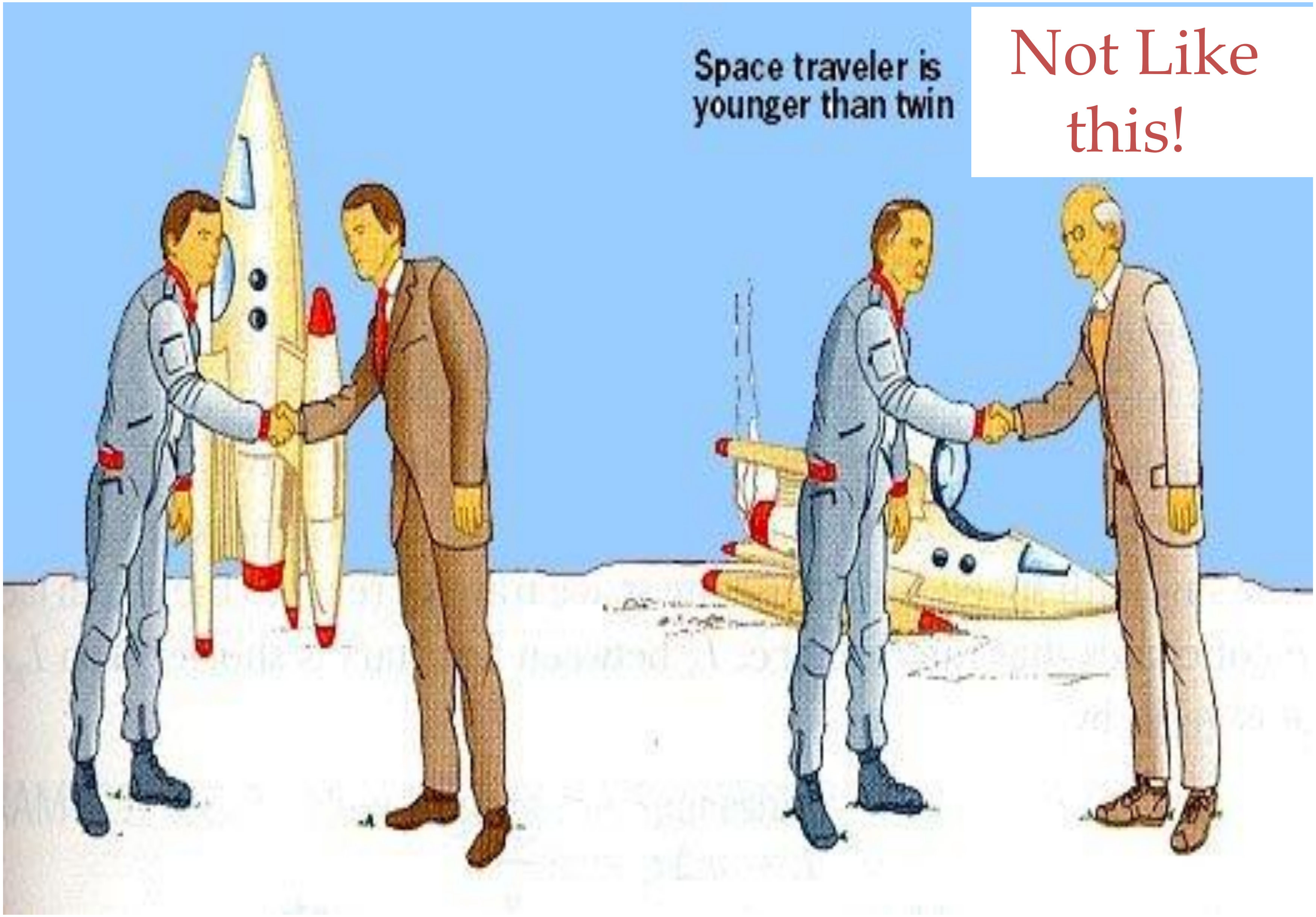
Approach Departure

Length Transformation

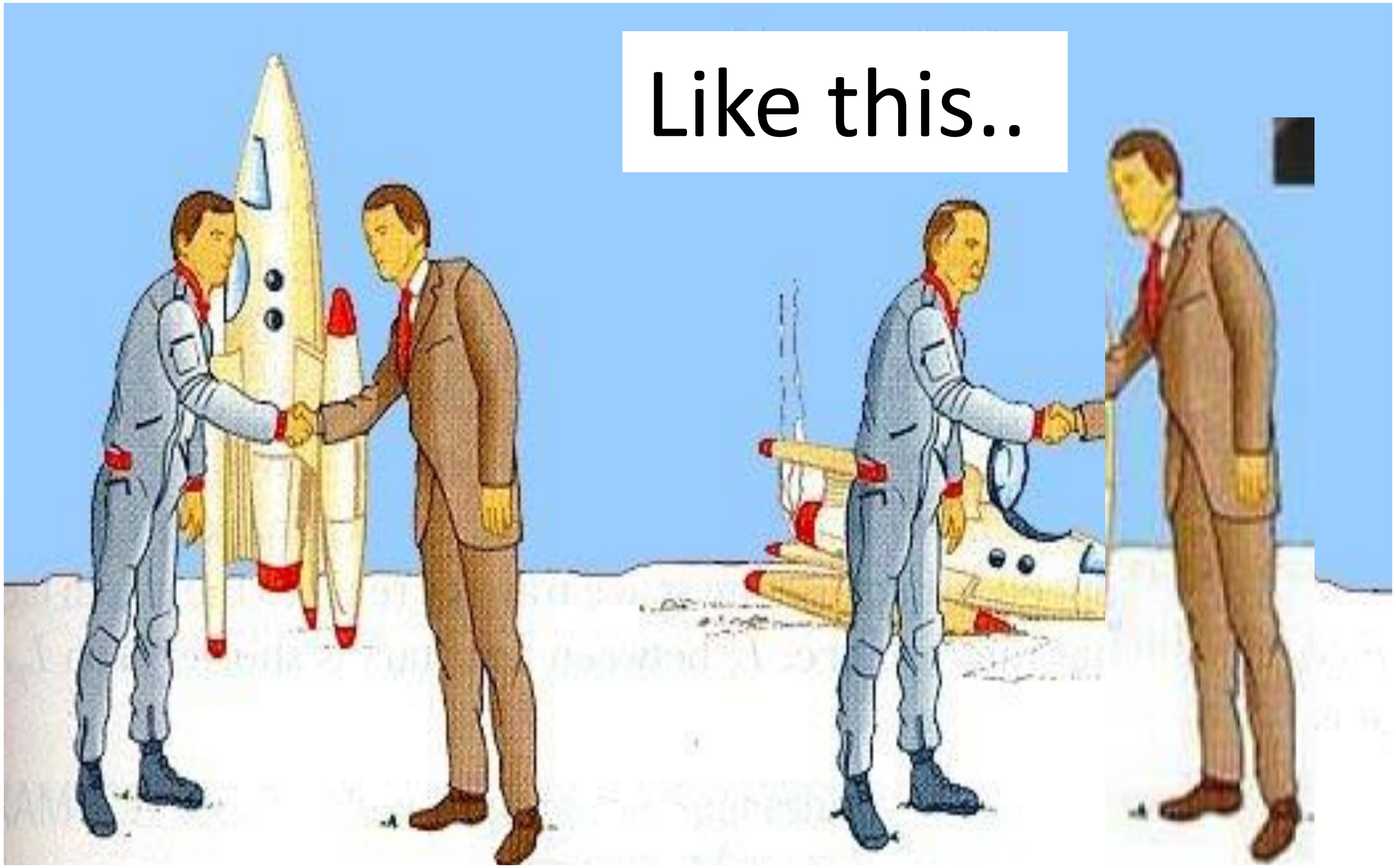


One of the consequences of the asymmetric time transformation is a symmetric solution to the Twin Paradox (Suleiman, *Physics Essays*, 2016)





Not Like this!

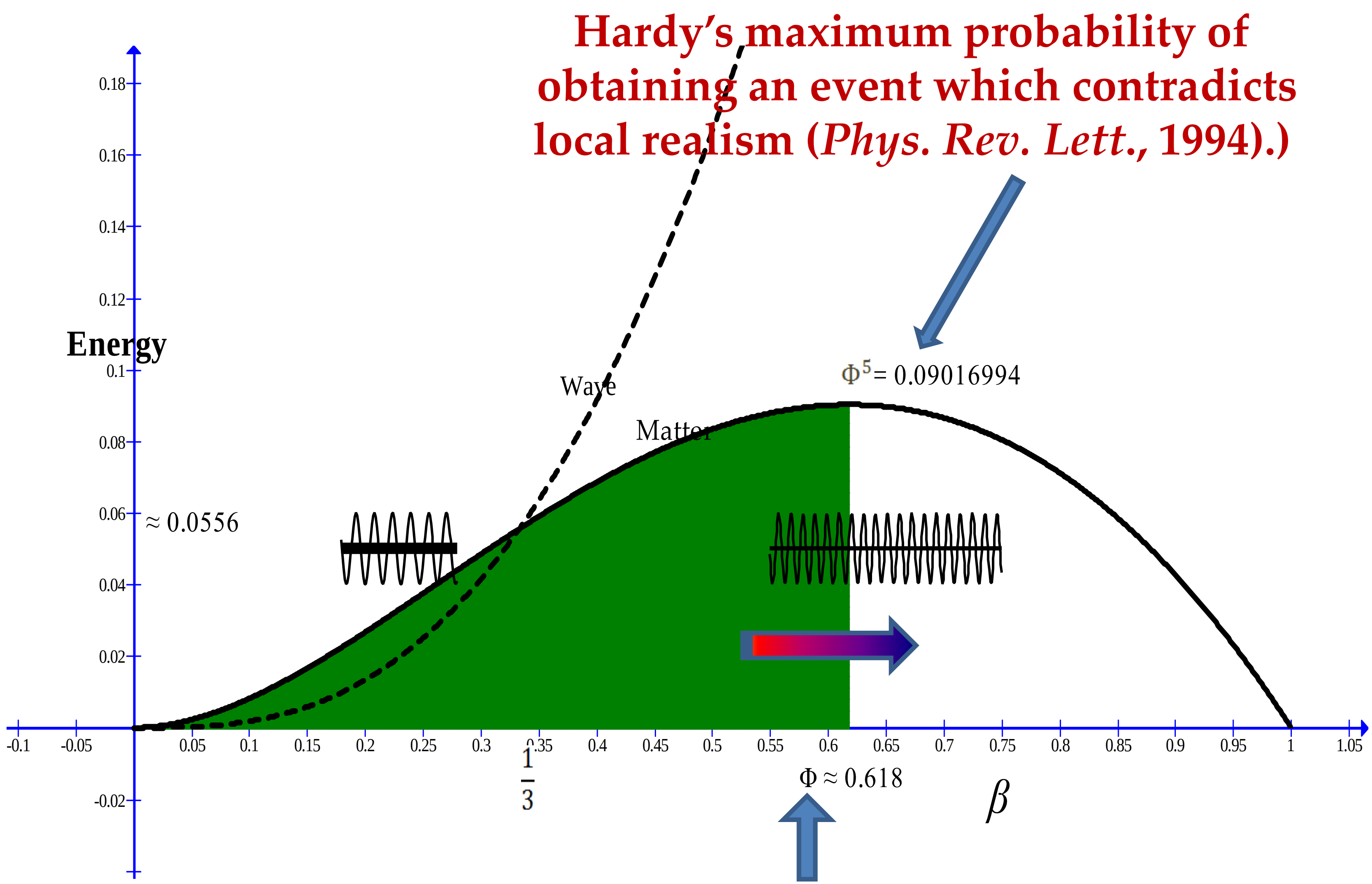


There once was a young pilot named Bright,
One day he left his twin named Dwight,
And took off to space by half the speed of light,
When he returned, after quite a long flight,
To his amazement he was same age as his twin Dwight!

Information Relativity Transformations

Physical Term	Relativistic Expression As function of β
Time	$\frac{\Delta t}{\Delta t_0} = \frac{1}{1-\beta}$ .... (I)

Matter and dual wave energies as functions of velocity



Coldea *et al.*,
quantum criticality at the GR (*Science*, 2010)

A snapshot of the Golden Ratio

"It is probably fair to say that the Golden Ratio has inspired thinkers of all disciplines like no other number in the history of mathematics"

Livio M., (2002). *The Golden Ratio: The Story of Phi, The World's Most Astonishing Number*

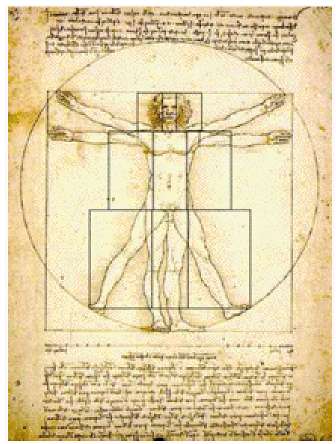
A snapshot of the Golden Ratio

Fibonacci Series $\boldsymbol{f_n}$ = 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, …

$$\lim_{n \to \infty} \frac{f_n}{f_{n+1}} = \frac{\sqrt[2]{5}-1}{2} = \Phi \approx \mathbf{0.618}$$

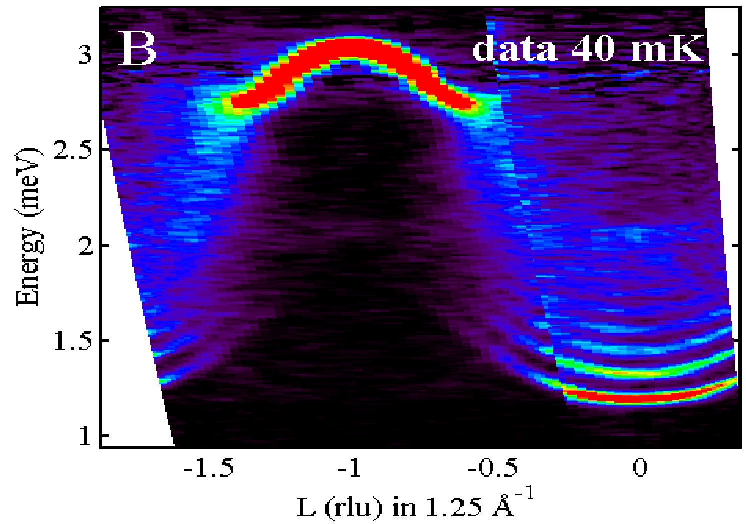
$\boldsymbol{f_9}$**= 34**

Klar, Fibonacci's flowers, *Nature*, 2002



Fair division of resources (Suleiman, *Games*, 2017)

Fair = Beautiful



Coldea et al., Science, 2010

Predictions & Explanations of Quantum Phenomena

Matter-wave duality

Quantum Entanglement

Quantum tunneling

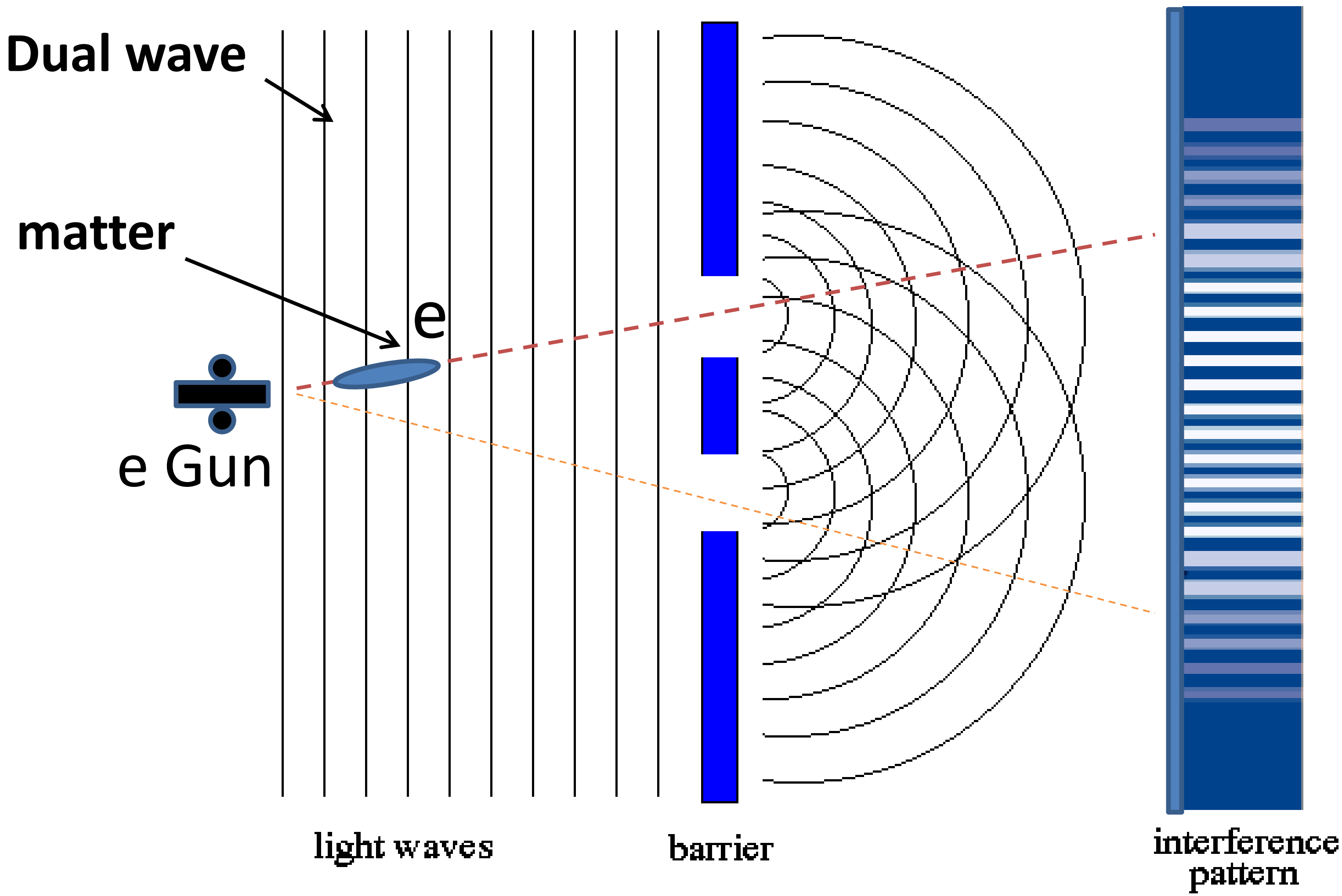
The hydrogen atom problem

Double slit Experiment

Strong Force (GIR)

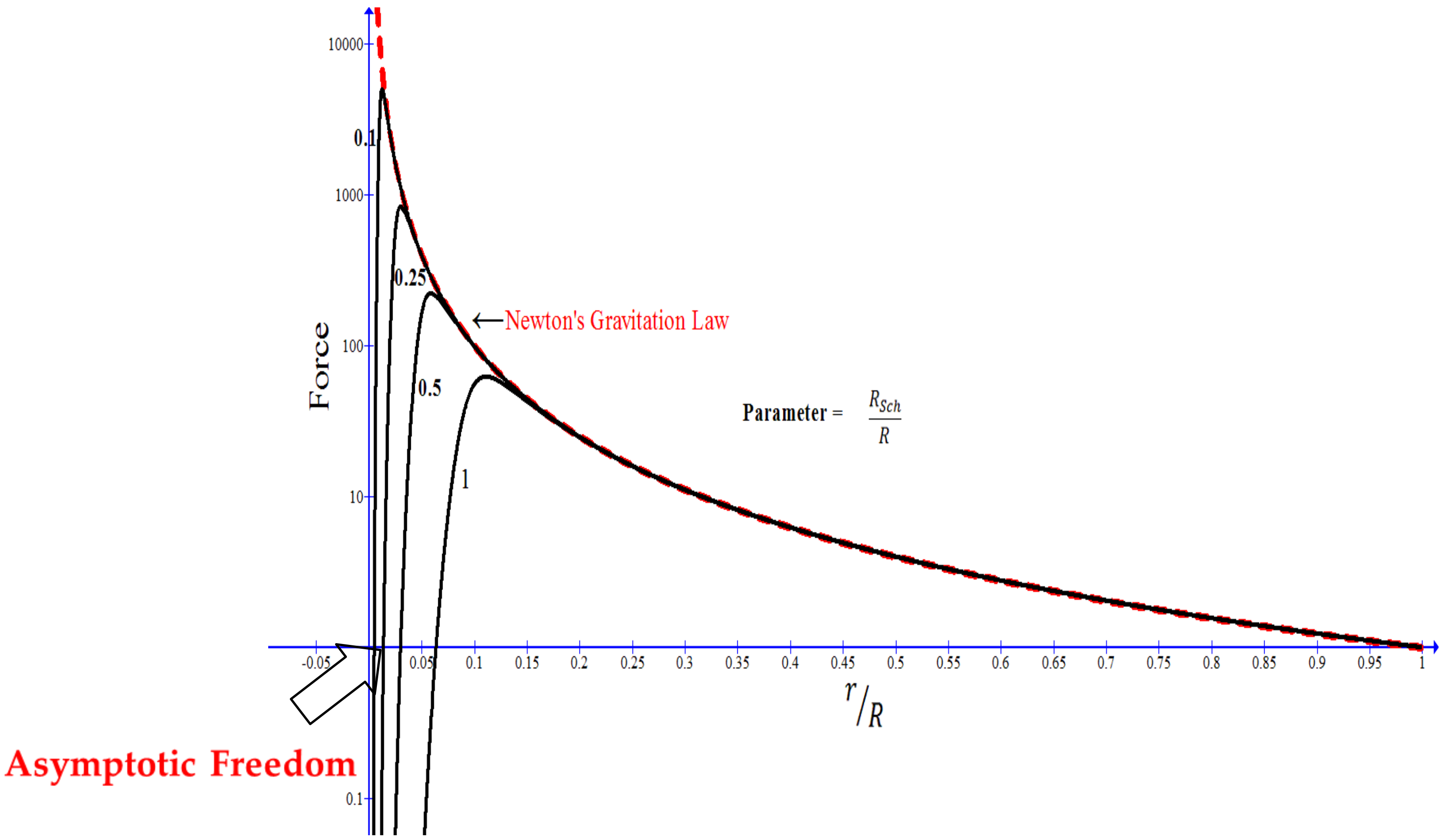
Confinement & Asymptotic Freedom (GIR)

Information Relativity Explanation of the Double-Slit Experiment

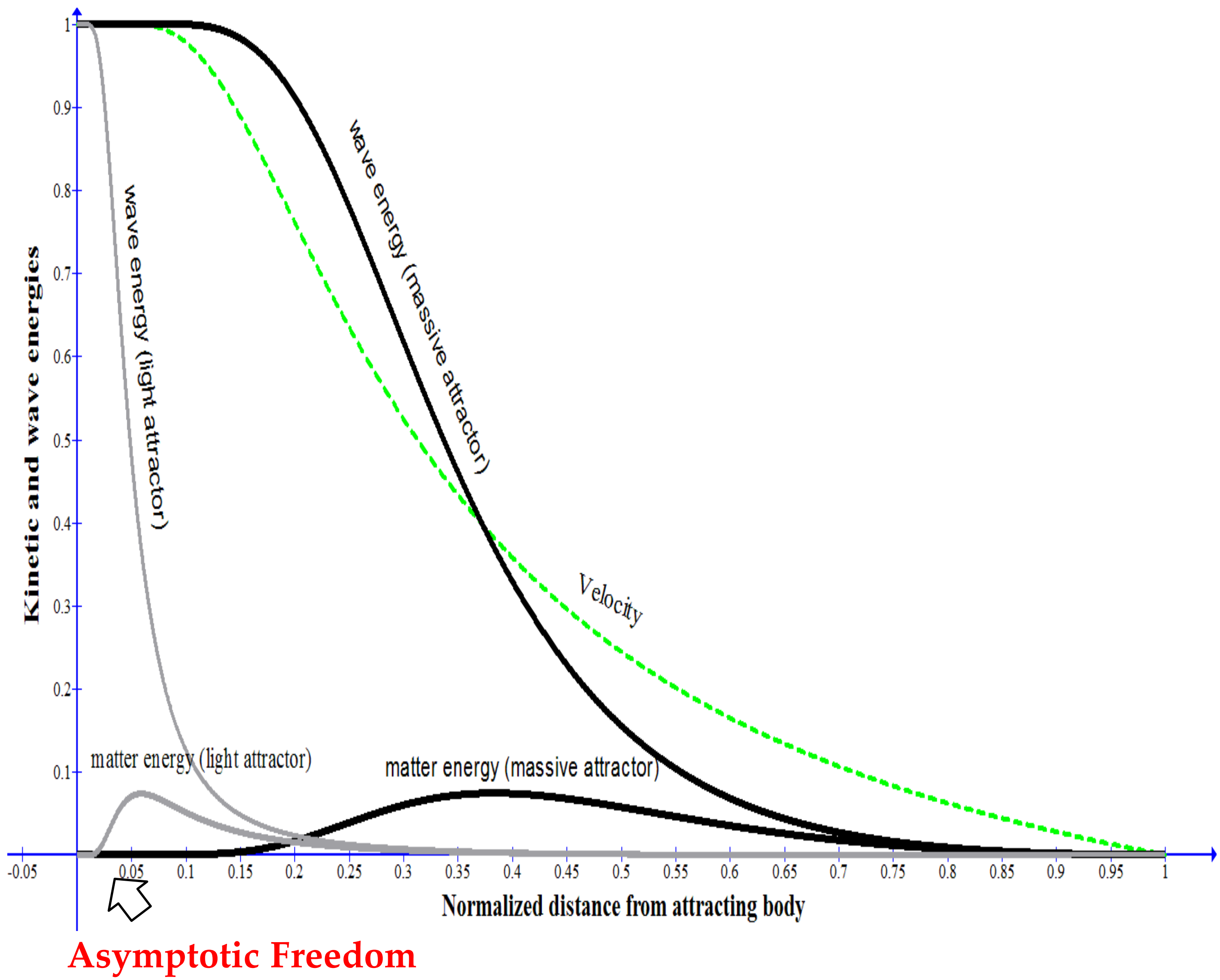


GIR main transformations

Physical Term	Relativistic expression as function of the distance r from the gravitating mass
Velocity (from rest)	$\beta = - \frac{1-e^{\frac{G M_0}{c^2}(\frac{1}{r}-\frac{1}{R})}}{1+e^{\frac{G M_0}{c^2}(\frac{1}{r}-\frac{1}{R})}} = \tanh(\frac{1}{4}\frac{R_{Sch}}{R}(\frac{R}{r} - 1))$
Time	$(\frac{\Delta t}{\Delta t_0})_G = \frac{1}{2}\ (e^{(\frac{1}{2}\frac{R_{Sch}}{R}(\frac{R}{r}-1))} + 1) = \frac{1}{1-tanh(\frac{1}{4}\frac{R_{Sch}}{R}(\frac{R}{r}-1))}$
Length	$(\frac{l}{l_0})_G = e^{(\frac{R_{Sch}}{R}(\frac{R}{r}-1))} = \frac{1+tanh(\frac{1}{4}\frac{R_{Sch}}{R}(\frac{R}{r}-1))}{1-tanh(\frac{1}{4}\frac{R_{Sch}}{R}(\frac{R}{r}-1))}$
Mass density	$(\frac{\rho}{\rho_0})_G = \frac{1}{e^{(\frac{R_{Sch}}{R}(\frac{R}{r}-1))}} = \frac{1-tanh(\frac{1}{4}\frac{R_{Sch}}{R}(\frac{R}{r}-1))}{1+tanh(\frac{1}{4}\frac{R_{Sch}}{R}(\frac{R}{r}-1))}$
Force	$F_{RN} = \mathrm{G}\ \frac{M_0\ m_0}{r^2}\ \frac{1}{1+\frac{l_0}{r}e^{\frac{R_{Sch}}{2}(\frac{1}{r}-\frac{1}{R})}}$
Kinetic energy density	$\frac{e_K}{e_0} = e^{\frac{R_{Sch}}{R}} \frac{(e^{\frac{R_{Sch}}{r}} - e^{\frac{R_{Sch}}{R}})^2}{(e^{\frac{R_{Sch}}{r}} + e^{\frac{R_{Sch}}{R}})^3}$
Wave energy density	$\frac{e_W}{e_0} = tanh(\frac{1}{4}R_{Sch}(\frac{1}{r} - \frac{1}{R}))^2 - e^{\frac{R_{Sch}}{R}} \frac{(e^{\frac{R_{Sch}}{r}} - e^{\frac{R_{Sch}}{R}})^2}{(e^{\frac{R_{Sch}}{r}} + e^{\frac{R_{Sch}}{R}})^3}$



Gravitational force as function of the distance from attracting body



Matter and wave energies as functions of the distance from the attracting mass

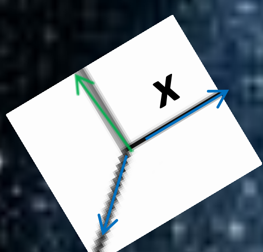
Applications to Cosmology

Dynamics and State of the Universe

A simplified quantum cosmology

1. Each galaxy is represented by a lumpy mass with negligible size relative to the observed universe.

2. Intergalactic interactions are weak, and thus are negligible.



To apply IR theory to cosmology, we express the aforementioned transformation in terms of redshift z. Using the time transformation and the Doppler formula, it is easy to show that:

$$z = \frac{\beta}{1-\beta}$$

$$\beta = \frac{z}{1+z}$$

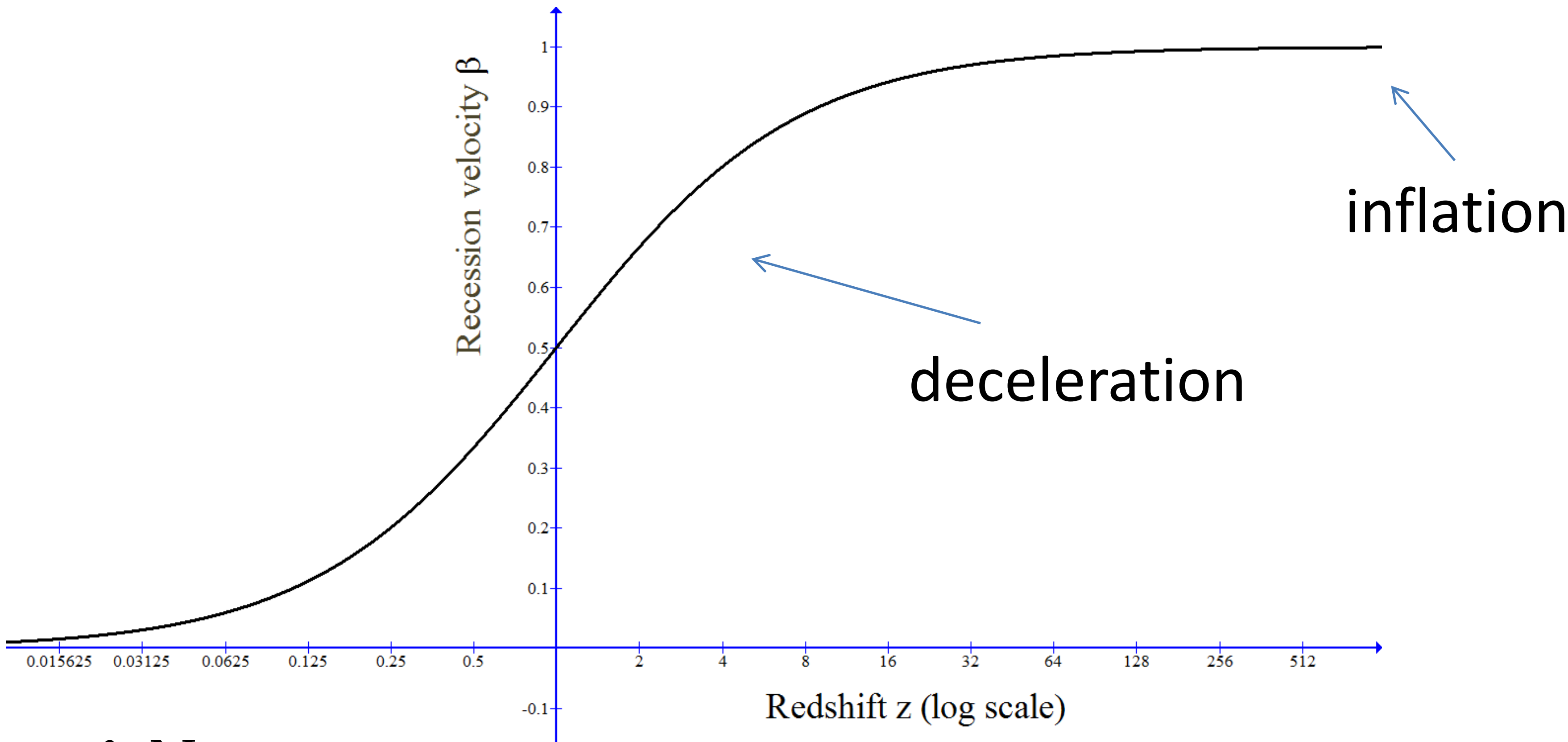
Table 2

Information relativity transformations in terms of redshift z

Physical Term	Relativistic Expression
Time	$\frac{\Delta t}{\Delta t_0} = z + 1$ (I′)
Distance	$\frac{l}{l_0} = 2z + 1$ (II′)
Mass density	$\frac{\rho}{\rho_0} = \frac{1}{2z+1}$ (III′)
Kinetic energy density	$\frac{e_k}{e_0} = \frac{z^2}{(z+1)^2(2z+1)}$ (IV′)
Wave energy density	$\frac{e_w}{e_0} = \frac{2z^3}{(z+1)^2(2z+1)}$ (V′)

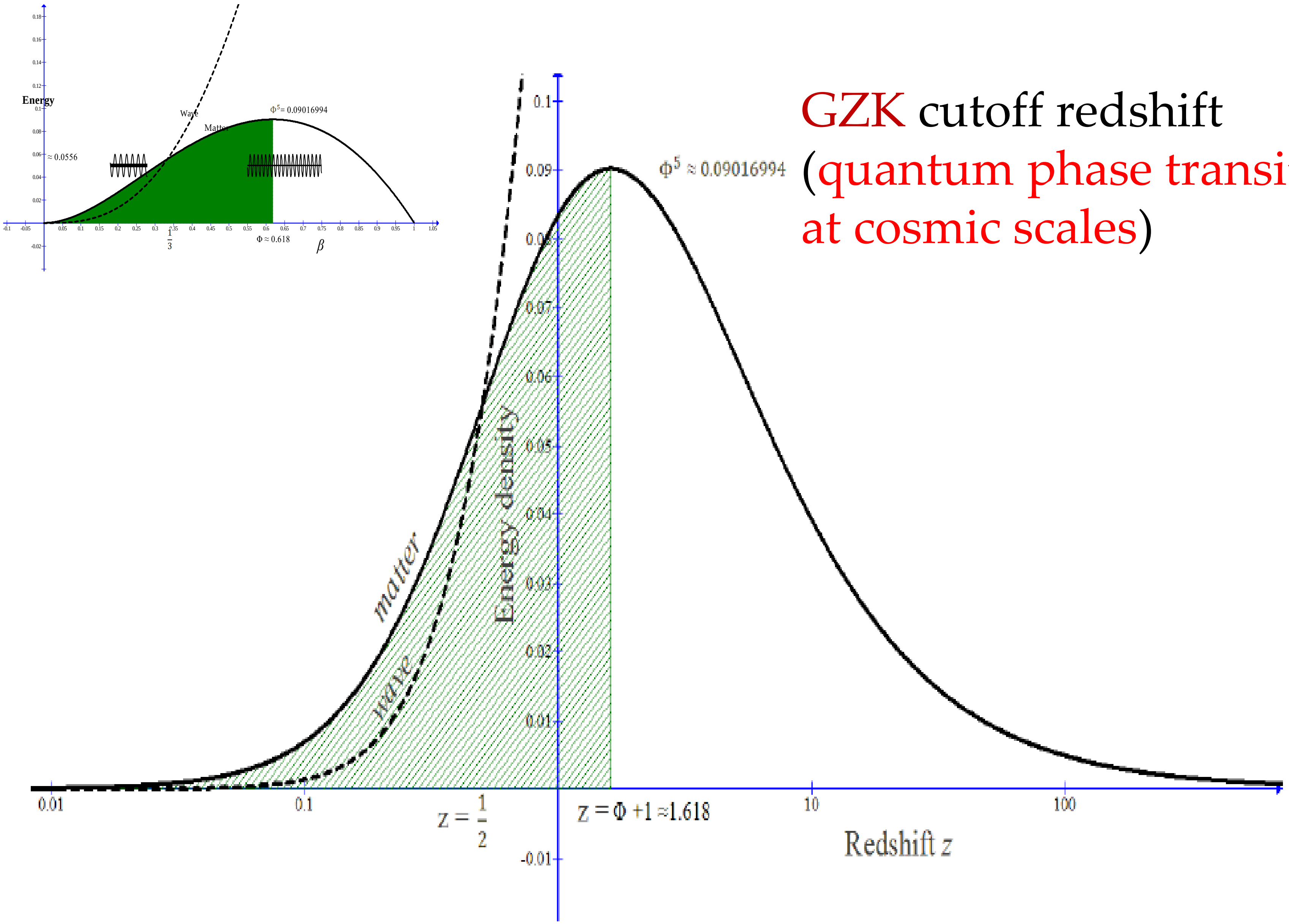
Recession velocity

$$\beta = \frac{z}{1+z}$$



Here & Now

BB



GZK cutoff redshift (quantum phase transition at cosmic scales)

Densities of matter kinetic energy and wave energy as functions of redshift z

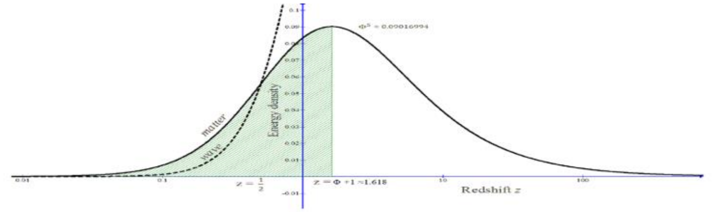


Figure 6: Densities of matter kinetic energy and wave energy as functions of redshift z

- The predicted decline in kinetic energy density at z ≈ 1.618 is in agreement with the GZK cutoff limit to the cosmic-ray energy spectrum [Greisen, *Phys. Rev. Lett.* ,1966; Zatsepin & Kuz'min, *J. Exp. Theor. Phys. Lett.*, 1966).

- It is also in good agreement with the HiRes experiment which show a break in the luminosity densities of QSO's and AGN's at about z=1.6, and with many discoveries of quasars, galaxies, and AGNs, indicating a break in luminosity densities at about z=1.6 (e.g., Thomson, *Journal of Physics, Conference Series,* 2006), including a discovery of high luminosity galaxies at redshift equaling exactly 1.618 [Gilli, *et al. ApJ*, 2003].

The proportions of matter energy and wave (dark) energy in any redshift range is given by:

Matter

$$\frac{e_k(z_1 - z_2)}{e_0} = \int_{z_1}^{z_2} \frac{z^2}{(z+1)^2(2z+1)}\, dz$$

$$= \frac{1}{2}\, ln\left(\frac{2z_2+1}{2z_1+1}\right) - \frac{z_2 - z_1}{(z_2+1)(z_1+1)}$$

Wave (Dark) Energy

$$\frac{e_d(z_1 - z_2)}{e_0} = \int_{z_1}^{z_2} \frac{2z^3}{(z+1)^2(2z+1)}\, dz$$

$$= (z_2 - z_1) + 2\frac{(z_2 - z_1)}{(z_2+1)\,(z_1+1)} - 2\, ln\left(\frac{(z_2+1)}{(z_1+1)}\right) - \frac{1}{2}\, ln\left(\frac{(2z_2+1)}{(2z_1+1)}\right)$$

Comparison with ΛCDM cosmologies

1. Wittman, et al., (*Nature*, 2000) z = 0.6 -1

ΛCDM ***Survey results:*** $\boldsymbol{\Omega_{matter} \approx \frac{1}{3}, \Omega_{\Lambda} \approx \frac{2}{3}}$

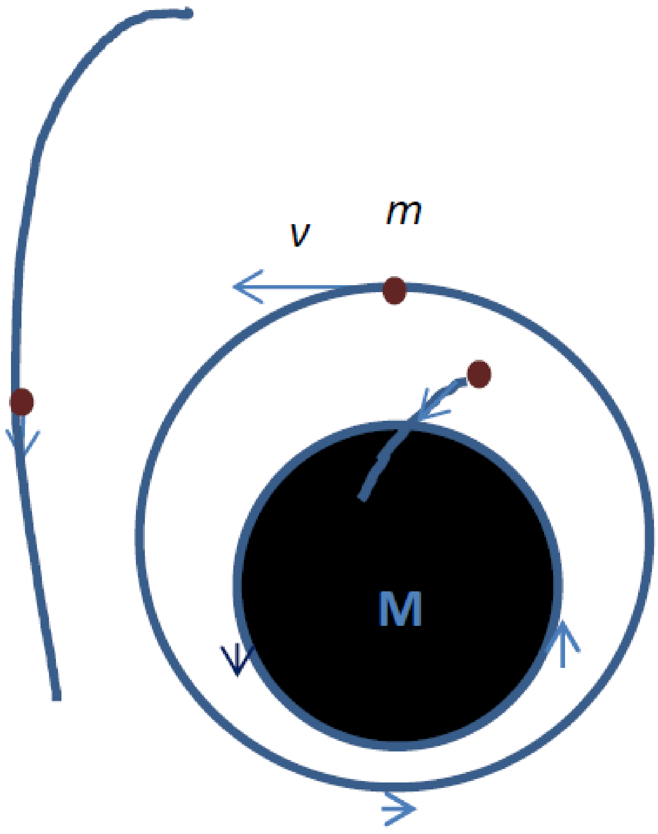
IR Prediction: $\boldsymbol{\Omega_{matter} \approx 0.38, \ \Omega_{\Lambda} \approx 0.62}$

2. Oguri, et al. (Ast. J. , 2008) z = 0 - 1.6

ΛCDM ***Survey results:*** $\boldsymbol{\Omega_{matter} = 0.23, \Omega_{\Lambda} = 0.77}$

Prediction: $\boldsymbol{\Omega_{matter} = 0.233}$ **, and** $\boldsymbol{\Omega_{\Lambda} \approx 0.767}$

IR explains the dynamics of a galaxy around its black hole, and predicts the Schwarzschild radius of the black hole ($R = \frac{2\,G\,M}{c^2}$), **without an interior singularity**



Summary

We propose a local realistic theory of everything, termed Information Relativity.

It is axiom free, simple and beautiful

It is expressed solely in terms of physical observables

Similar to de Broglie-Bohm's theory, it yields a realistic matter-wave duality model.

Unlike de Broglie-Bohm's model is does not suffer from the "collapse problem". The collapse of the dual wave to corpuscular matter is explained mechanically.

IR unifies physics, and explains several standing issues in quantum physics and cosmology

- ✓ Application of IR to cosmology yields a simple quantum cosmology, in which dark matter and dark energy are, respectively, cosmic quantum matter, and dual wave energy.

- ✓ The model yields good predictions of the amounts of matter and dark energy reported by **Λ**CDM cosmologies

IR is still in its infancy, and there is a lot to be done …

Electrostatic & Electromagnetic fields

Non-linear motion

Rotating bodies

Many-body interactions

……….

………

Concluding remarks

- The current model of reality is fragmented, mathematically cumbersome, expressed in non-physical terms, full of inner contradictions, non-bridgeable with Newtonian physics, and incapable of answering fundamental questions, like the nature of dark matter and dark energy.

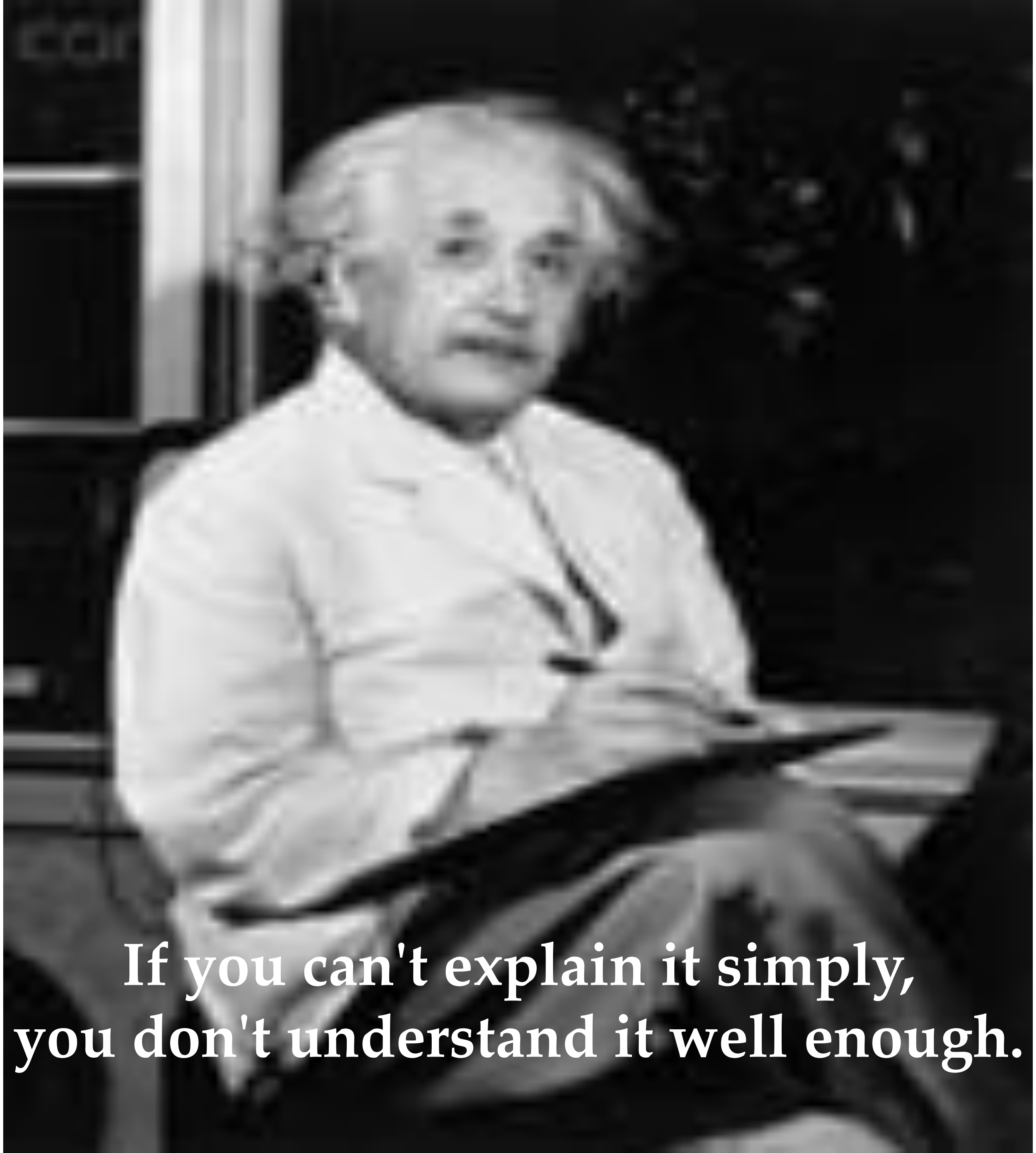
- In contrast, IR is a unifying, coherent, non-axiomatic, simple and beautiful model, expressed only in physical variables.

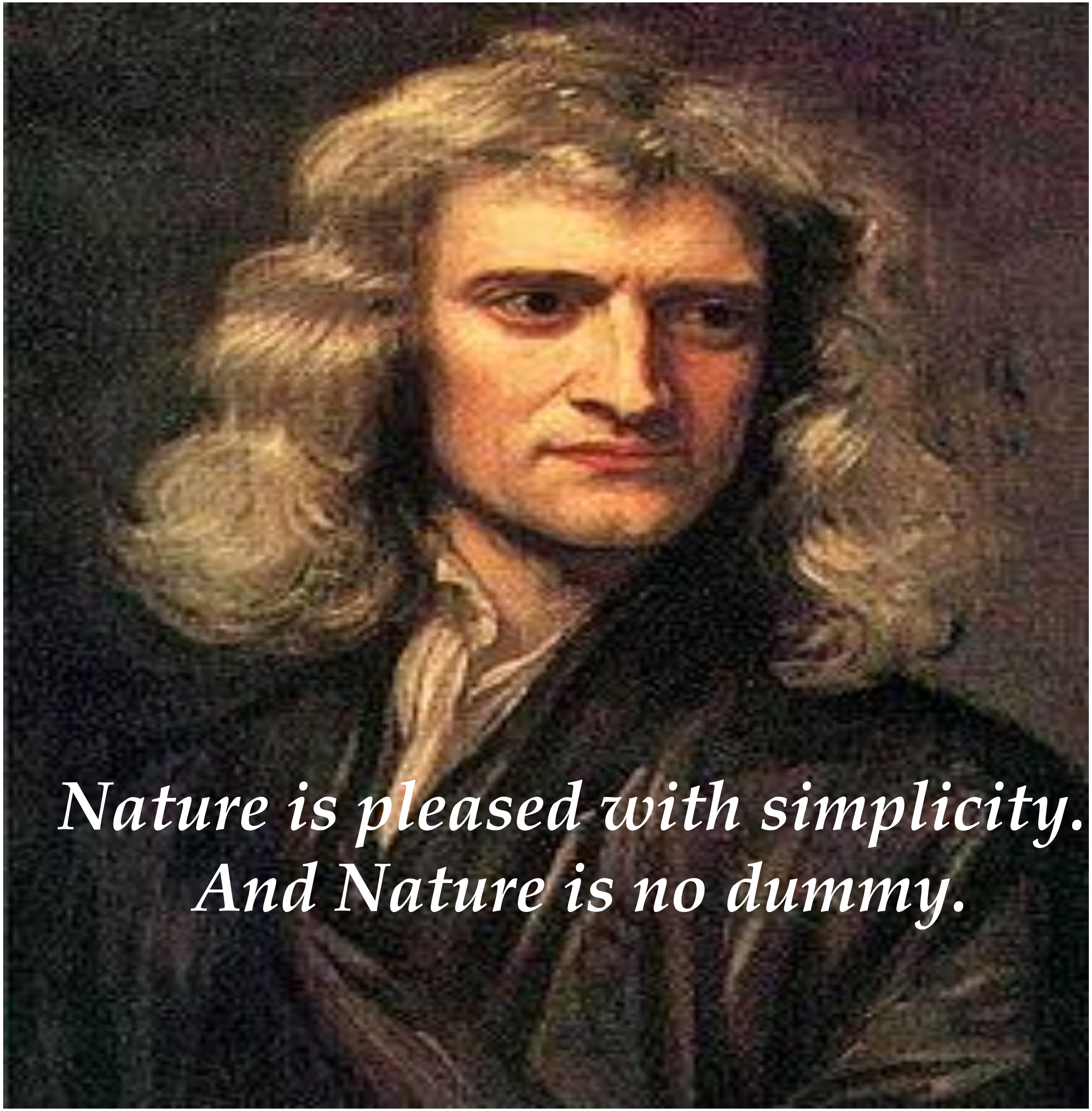
- It preserves continuity with Newton's physics.

- It provides plausible, and easy to test explanations of fundamental questions of physics.

- Obviously, IR constitutes a huge paradigm shift in all physics. The difficulties in merging it with contemporary physics are expected to be enormous, and so are the social and psychological difficulties which would accompany such merger.

- However, the fact that it is grounded only on physical facts with no axioms, coupled with its unifying property and unquestionable success in predicting and explaining a multitude of important physical phenomena, should be enough to convince the unbiased scientist, that it deserves a chance to be put for experimental testing.


If you can't explain it simply,
you don't understand it well enough.


Nature is pleased with simplicity.
And Nature is no dummy.


Thanks for your
attention