Gravity, Momentum, and the Potential Energy Field

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Abstract

Relativity is based upon just three guiding principles.[i]

A. The speed of light is constant for all observers.
B. Observations made from every inertial reference frame are equally valid.
C. Inertia and gravitational attraction are identical.

To these, I propose adding a fourth:

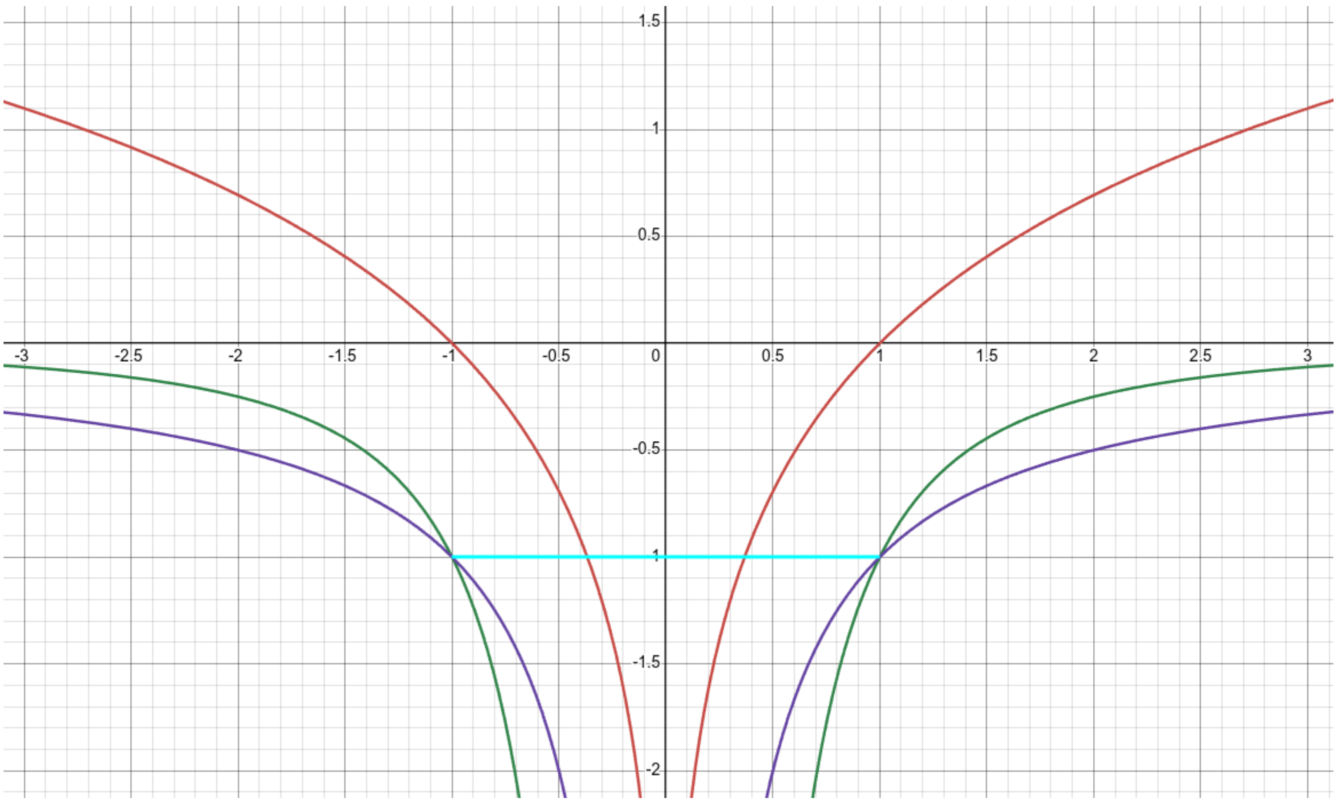
D. Energy density must be conserved.

This simple addition leads to a model with particles of fixed and finite size in a Euclidean field of potential energy. The model is more simple and intuitive than general relativity. It also shows a "flattening" of gravitational attraction in low energy areas like the outer regions of rotating galaxies, where general relativity is known to fail.

The Potential Energy Field

If we are to take seriously the conservation of energy, or more particularly energy density, we must first have something to conserve. That something is the field of potential energy, from which all other fields withdraw their energy. Potential energy is not an abstract bookkeeping term, but a real field with profound impact. But what does this potential energy field look like?

To begin with, the vertical range of the field must go from zero (no potential energy) to some large but fixed and finite number. The graphics throughout this paper show fields with the horizontal representing space and the vertical axis representing potential energy, labeled by how much has been withdrawn.



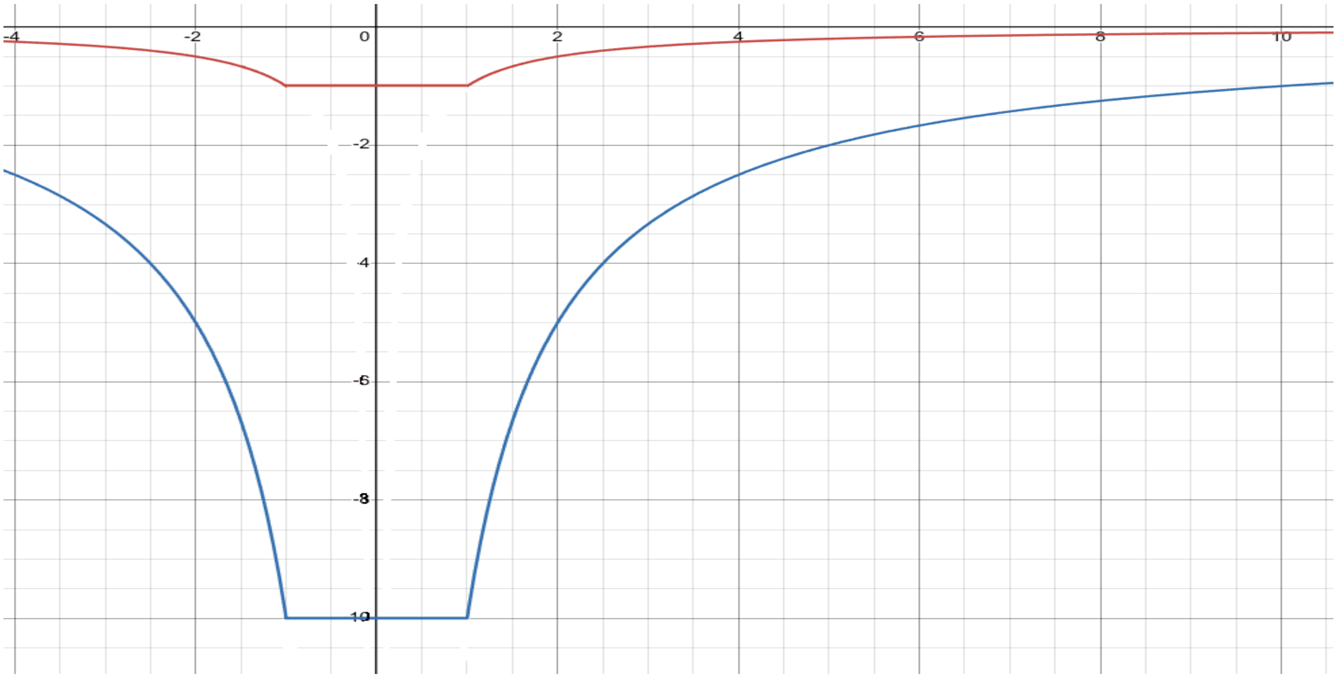
Red is position $-\ln|x|$, green is velocity $-|1/x|$, purple is acceleration $-|1/x^2|$.

Looking at the graph above, we clearly see that for a test particle of mass 1, the acceleration and velocity curves cross at $x=\pm1$, which is where the position curves cross from positive (external) to negative (internal). Therefore, our particle must have a fixed and finite radius of 1. It withdraws energy proportional to its rest mass.

We shall see that the fixed and finite radius of all particles has profound implications. For one, it eliminates the problem of mathematical infinities and singularities. For another, it allows particles to have an interior wherein local properties may reside.

Particles cause divergence, gradients, and sometimes curl in the potential energy field.

The potential energy field having a bottom means that black holes are hollow shells of maximal energy density surrounding an absolute nothingness with zero potential energy. It having a top means that calculations with infinite energies are forbidden.



Stationary particles of mass 1 and 10.

Work is that which deforms the potential energy field. It is bound energy.
Rest mass (m_0) is work that withdraws energy from the potential field evenly across a particle.
Force is the gradient along the deformations in the field. It is free energy.
The **speed of light** (c) is the fixed rate at which change propagates through the field.

Momentum

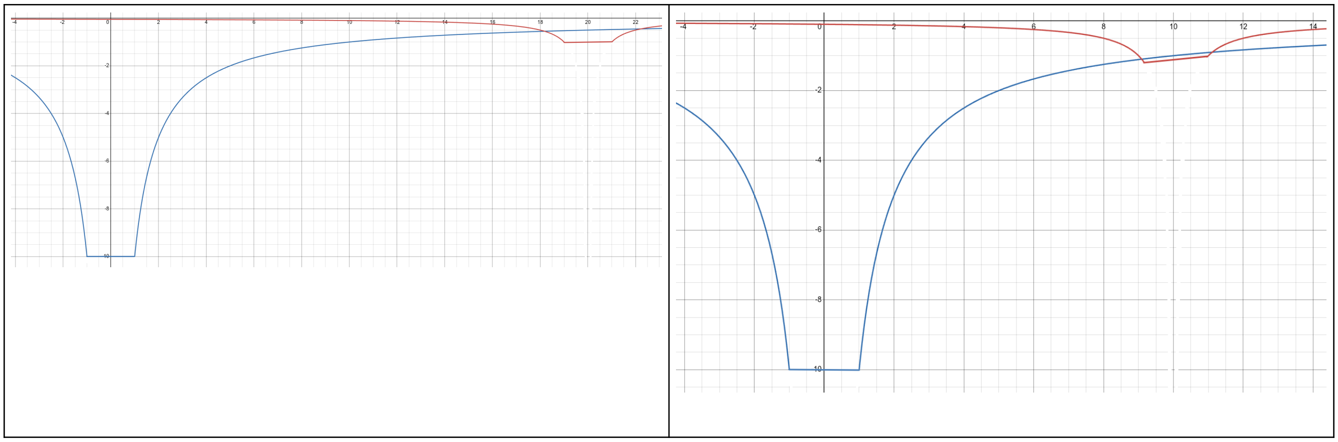
Physics makes wide use of the derivative, the slope at a point on a curve, to compute things like force. That simplifies in this model to energy gradients *across* a particle. Momentum, or inertia if you prefer (as they are identical), therefore becomes an inherent property of a particle - the energy gradient across its diameter. Thus, the force of gravitational attraction and inertia are exactly the same - energy gradients.

Momentum is the internal energy gradient across a particle. It is a property of particles.
Gravity is the energy gradient along the field, and is a property external to particles.

These gradients constantly influence each other. "Spacetime tells matter how to move; matter tells spacetime how to curve." [ii] In the absence of a gradient in the field, the particle's gradient, its inertia, will remain unchanged. In the presence of a gradient, the particle's gradient will change in proportion to the gradient and the time spent with that gradient. Each particle behaves as if its internal gradient were flat, "viewing" the field from its own "perspective".

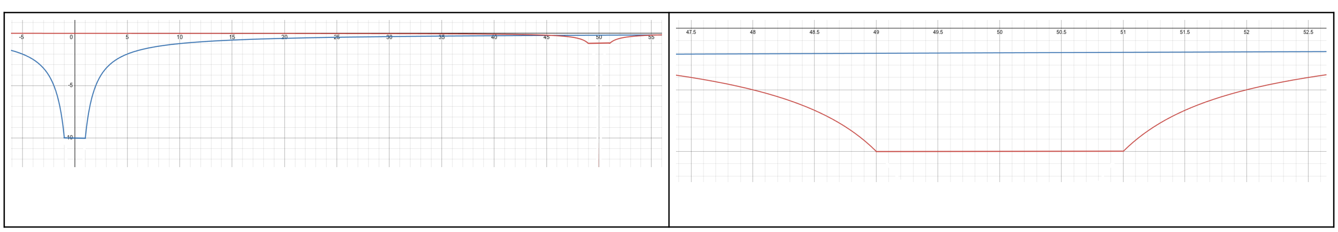
Gravity

Since particles are not point-like, we cannot use the standard $1/x^2$ force laws. We instead use calculated gradients. Fortunately, all particles have the same fixed radius and the field is conservative. That lets us compute a gradient along a curve segment as the difference of the ends of the segment, ignoring everything in between. This is a simplification, as the particle must be physically capable of crossing every subsegment without running out of energy in that direction. A key feature is the radius of the particle *r*, so the gradient moving to the left from points a to b is calculated from a+r to b-r.



The red particle accelerates towards the blue particle, which is held in place to simplify.
Particle gradients are intended as visual examples only and are not to any scale.

This overlap replicates the "extra" force of gravity shown in general relativity. The more closely it approaches a massive object, the more the gradient across a particle diverges from the slope at its center. In addition, particles moving slowly along a weak gravitational gradient spend more time being influenced *by the same points* in the field, effectively "flattening out" the gravitational force in slow/weak areas. This better explains the rotation of galaxies, where general relativity is known to fail. The slower you go, the more quickly you are accelerated.



The red particle is far from the blue, where the gradient is much weaker but always present.

What is the *effective* gradient felt by particles moving from x=100 to x=40 at different rates?

Number of divisions:	1 (Δ=62)	2 (Δ=32)	3 (Δ=22)	4 (Δ=17)	6 (Δ=12)
Total gradient:	-0.01573	-0.01615	-0.01661	-0.01709	-0.01806

It's important to recognize that a field gradient altering a particle's energy gradient does not directly effect the field gradient itself. No energy is lost or gained *by the field gradient* in this transaction - only the particle changes. Of course, a change in the particle will immediately begin to propagate as a change to the field. But that's an indirect effect, and only to the deformations imposed upon the field by the particle itself.

Momenergy

Given an energy differential across a particle, how do we determine its properties? What does it mean We shall use "natural units" throughout, where the speed of light $c = 1$.

Rapidity (p°) is the *tangent* of the gradient angle. This is a relativistic quantity that stands in for **momentum**. It does *not* depend upon mass. $p° = \gamma v$.
Velocity is the *sine* of the angle. It is also the Lorentz alpha factor times the momentum: $v = \alpha p°$.
The Lorentz **alpha** factor (α) is the *cosine* of the angle. This is the subjective, "proper" time of a particle.
The Lorentz **gamma** factor (γ) is the *secant* of the angle. This is the inverse of alpha.

Acceleration formulae:
Rapidity: $p°_{a+b} = p°_a + p°_b$
Gradient: $\theta_{a+b} = \arctan(\tan \theta_a + \tan \theta_b)$
Velocity: $v_{a+b} = \sin(\arctan(\tan(\arcsin v_a) + \tan(\arcsin v_b)))$

Adding relative velocities: A stationary observer sees a ship moving at speed A. The ship fires a cannonball directly forward along its line of motion moving (with respect to A) at speed B. What speed does the observer see the cannonball have?

Collinear relative velocity addition: $v_{a+b} = (v_a + v_b) / (1 + v_a v_b) = \gamma_a \gamma_b (v_a + v_b) = (v_a + v_b) / \alpha_a \alpha_b$
$A = 0.5c$, $B_A = 0.7c$
$(A+B_A) = (0.5 + 0.7) / (1 + 0.5 \cdot 0.7) = 0.888c$
$(A+B_A) = (0.5 + 0.7) / (\cos(\arcsin 0.5) \cdot \cos(\arcsin 0.7)) = 0.888c$

To switch reference frames, rotate by the appropriate gradient angle, which is identical to subtracting the rapidity. In this model, energy differentials are conserved and agreed upon by all observers. The proper time of a particle is essentially irrelevant to the computations, as it is already included in the tangent of the gradient. We don't care about what a particle *thinks* is going on (so to speak). We're measuring what the energy is doing.

But wait! Isn't this supposed to be an energy gradient? How does it work with rapidity?

Momenergy ($e° = p°c$) is the energy due to momentum. It is the rapidity multiplied by the speed of light. Just as rapidity is the relativistic equivalent of momentum without mass, momenergy is the equivalent of **kinetic energy** without mass. Momenergy is what we're really measuring the gradient of. But, when using the "natural units" where $c = 1$, numerically $p°c = p°$.

The energy differential around a particle, combined with the squeezing and stretching of the field around it as it moves relative to the speed of light, results in blue shift and red shift effects.

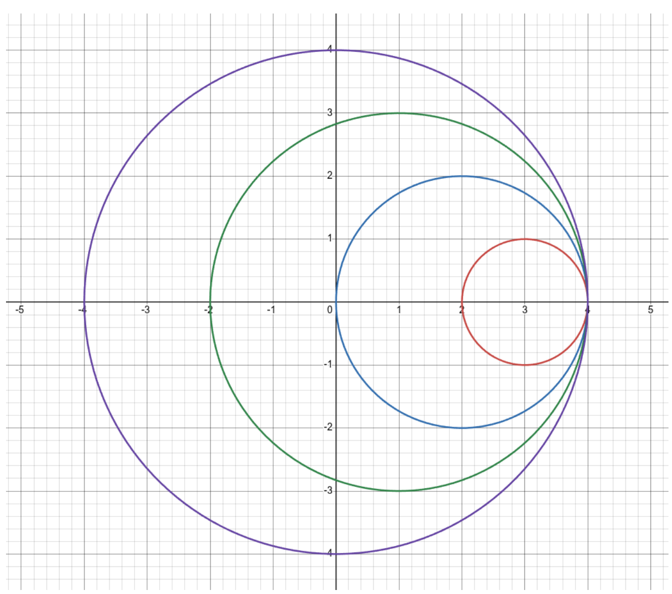
Momenergy = p°c = γvc.
Energy at the edge of a particle = rest mass + (momenergy · (1 + cos Φ) / 2), where Φ = off-axis angle.
Average kinetic energy (KE°) = half the momenergy = ½e° = ½p°c = ½γvc.
Average total energy (E) = rest mass + average kinetic energy = m_0 + KE°.

Photons

Photons behave differently from massive particles in the potential energy field. They have energy but no mass. This implies they are two dimensional objects, having width and height without length - a disc moving through space like a sail. This gives them a *vertical* internal energy "gradient", which is more properly a line segment. Sin 90° = 1, so they always move at the speed of light. Cos 90° = 0, so they have no proper time. Tan 90° = infinity, so they can neither slow down nor speed up.

Energy gradients in the direction of motion alter the energy of a photon. If it ever reaches zero energy, it ceases to exist. Energy gradients orthogonal to the direction of motion (along the diameter of the disc) alter the direction of motion. Photons cannot reverse course, but they can and do change direction. They can even orbit a remarkably massive object.

Since they move at the speed of propagation, photons have no effect upon the potential energy field ahead of themselves. Since their internal energy returns to the baseline (no rest mass), they have no effect upon the potential energy field directly behind themselves, either. However, they do create a lateral gradient around the edge of the disc.



Oversimplified drawing of a photon in motion to the right, gradients propagating laterally.

Summary of Definitions and Formulae

Particles cause divergence, gradients, and sometimes curl in the potential energy field. Changes in the field propagate at the speed of light.

The speed of light (c) = 299,792,458 m/s = 1 in "natural units".

v = **velocity** as a fraction of c ($0 \le v \le 1$).

Lorentz **alpha** (α) = $\sqrt{(1-v^2)}$ = cos θ = cos(arcsin v) = relativistic factor ($0 < \alpha \le 1$).

Lorentz **gamma** (γ) = $1/\alpha = 1/\sqrt{(1-v^2)}$ = relativistic factor ($1 \le \gamma$).

Rapidity (p°) = $\gamma v = v/\alpha$ = tan(arcsin v) = tan θ = momentum gradient without the rest mass.

Momenergy (e°) = $p^\circ c$ = γvc = energy gradient without the rest mass.
When c = 1, momenergy is numerically equal to rapidity.

Gradient angle (θ) = arcsin(v) = arctan(p°) = arctan(e°) = arccos(α)

Acceleration formulae:
Rapidity: $p^\circ_{a+b} = p^\circ_a + p^\circ_b$
Momenergy: $e^\circ_{a+b} = e^\circ_a + e^\circ_b$
Gradient: $\theta_{a+b} = \arctan(\tan\theta_a + \tan\theta_b)$
Velocity: $v_{a+b} = \sin(\arctan(\tan(\arcsin v_a) + \tan(\arcsin v_b)))$

The collinear relativistic velocity addition formula:
Your stationary perspective of moving body a's perspective of collinear moving body b:

$v_{a+b} = (v_a+v_b)/(1+v_av_b) = \sin(\arctan((v_a+v_b)/(\cos(\arcsin v_a)\cdot\cos(\arcsin v_b))))$

$\theta_{a+b} = \arctan((\tan\theta_a / \cos\theta_b) + (\tan\theta_b / \cos\theta_a))$

$p^\circ_{a+b} = \gamma_b p^\circ_a + \gamma_a p^\circ_b = \gamma_a\gamma_b(v_a+v_b) = (v_a + v_b) / \alpha_a\alpha_b = (v_a+v_b)/(\cos(\arcsin v_a)\cdot\cos(\arcsin v_b))$

$\sin\theta = v$
$\cos\theta = \alpha$
$\tan\theta = \sin\theta / \cos\theta = e^\circ = p^\circ c = \gamma vc$

Average kinetic energy (KE°) = $\frac{1}{2}e^\circ = \frac{1}{2}p^\circ c = \frac{1}{2}\gamma vc$ = kinetic energy without the rest mass.
Rest energy = (rest mass)$\cdot c^2 = m_0c^2$
Average total energy (E) = rest energy + $KE^\circ = m_0c^2 + \frac{1}{2}p^\circ c$
Energy at the edge of a particle = $m_0 + (e^\circ \cdot (1 + \cos\Phi) / 2)$, where Φ is the off-axis angle.

The sum of the gradients across each subsection of a field is equal to the total gradient across the field. This is simply the difference between the energy level at the end minus the energy level at the beginning.

References

i Albert Einstein, "Relativity, The Special and General Theory", translation by Robert W. Lawson

ii John A. Wheeler, "Geons, Black Holes and Quantum Foam: A Life in Physics"