

The Paradise of Thinking

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The Enemy of Science is not Error - but Inertness.

-- Henry Thomas Buckle (1821-1862), English historian

“If you can't beat them, join them” has no justification in science, otherwise we would never had a *Copernicus*, a *Kepler*, a *Galilei*, a *Giordano Bruno*, who courageously rose against dogma. Inertness is the easy path to dogma and a “closed case” label on a still open issue. Physics suffers from too many premature “case closed” labels. There is no closed case in natural science - that is one of its trademarks. The other trademark is self-correctness. Performing an experiment or setting up a theory means to keep track of conditions or assumptions, respectively. The photoelectric effect, Maxwell's equations, the “ether hassle”, $E = mc^2$, the Michelson-Morley experiment, quantization, tunneling, ... - the list is long and none of its items is a closed case. Take an elementary (really?) “down-to-earth” problem like the oblique throw: Its customary treatment is inconsistent. You don't have to do any calculation to see that this “flat earth” result is definitely wrong, violating time honored physical principles, no matter how satisfactory its numerical outcome. If we fail here to arrive at consistency, how can we hope to cope with the above list? It's rather a matter of psychology than of science that we don't slow down in our jumping at conjectures and keep our feet on solid ground instead and release a result only if we are (at least halfway) sure that it will stand the “test of time”. Practically all fields of physics require continuous fresh thinking. Science is the “paradise of thinking” and we should not let inertness expel us from it!

1. Dissidents? Upstream Swimmers!

“Dissident” from the Latin *dissidere* = to be separate, to disagree, to contradict. That sounds somewhat passive. It's more comforting to call non-conformists according to what they do instead of what they don't. I prefer to be an *upstream swimmer*. Upstream swimmers struggle their way against the mainstreamers, looking into a different direction, and (avoiding inertness) make an effort to get back to the sources of a problematic development, both scientifically and historically.

2. Case Closed? No – Just Dogma!

Dogmas are dangerous because they keep science from being self-correct. Giving an “old” problem a second (and third, if needed) thought, we discover many dogmas responsible for inconsistent physics teaching. It's important to stay simple and transparent in our considerations so we know what we are doing and others can follow us; upstream swimming is hard enough all by itself. The following considerations open a grab bag of dogmas as an appetizer to search and find more for yourself. Let us start with a familiar (simple?) textbook example - the dogma of the *parabolic path* and look at it in more detail as it is a lucid and easy to follow example for our excursion.

3. Down to Earth - the Oblique Throw

This is quite customary in practically all textbooks: The path of an object (mass m) thrown at an angle ψ under the combined effect of a ballistic constant initial velocity (v_0) initially and of earth's gravity (g) is presented as a *parabola*. Parabola? No, the path *can't* be parabolic under the initial condition that v_0 is (usually much) smaller than the escape velocity v_{esc} . Were the trajectory parabolic, i.e. an *open path*, m would eventually escape

to infinity, thus violating energy conservation. The usual conditions of the thought experiment assume v_0 too small even to keep m in orbit at the surface equilibrium velocity v_{equ} , let alone let it escape to infinity. The square of the equilibrium velocity v_{equ}^2 to keep an object in orbit at earth's surface (corresponding to the academic case of tangential throw, $\psi = 0$, with initial v_{equ}) equals the gravity potential at Earth's surface, GM/R , with G the gravitation constant, M and R Earth mass and radius, respectively. (Yes, velocities squared make swell dynamic potentials; there's nothing strange about this - it is done all the time in physics, without maybe realizing the idea of the dynamic potentials behind that concept, see below.)

The kinetic energy for escape into infinity

$$\frac{v_{\text{esc}}^2}{2} = \int_R^\infty \frac{GM}{r^2} dr = \frac{GM}{R} = v_{\text{equ}}^2 \quad (1)$$

(canceling m) delivers the familiar escape velocity $v_{\text{esc}} = \sqrt{2} v_{\text{equ}}$. Back to the throw with initial v_0 .

Introducing the ratio $\beta^2 = \left(\frac{v_{\text{esc}}}{v_0}\right)^2$ of *two dynamic potentials* as a handy parameter we try a more realistic approach and replace the constant $g(R)$ by $g(y) = \frac{GM}{(R+y)^2} \approx \frac{GM}{R^2 + 2Ry} = \frac{v_{\text{equ}}^2}{R + 2y}$.

Performing the usual procedure with this $g(y)$, and considering the special case $\psi = \pi/4$ for simplicity we arrive at the general equation $\beta^2 x^2 + 2y^2 - 2xy - Rx + Ry = 0$.

Indeed, this gives us different types of cone sections, depending on β^2 (Fig. 1) as desired. For $2\beta^2 > 1$ we get a variety of

ellipses (not Kepler ellipses!). Even the limiting cases look reasonable: For $\beta = 0$ (infinite v_0), the path is a straight line ($y = x$) and for infinite β (zero v_0) the object stays at the origin. When a trajectory passes through a maximum, the apex is up, and when it is up we have an ellipse. The parabola ($2\beta^2 = 1$), a unique case by the way, is a path of no return, with its apex pointing the other way!

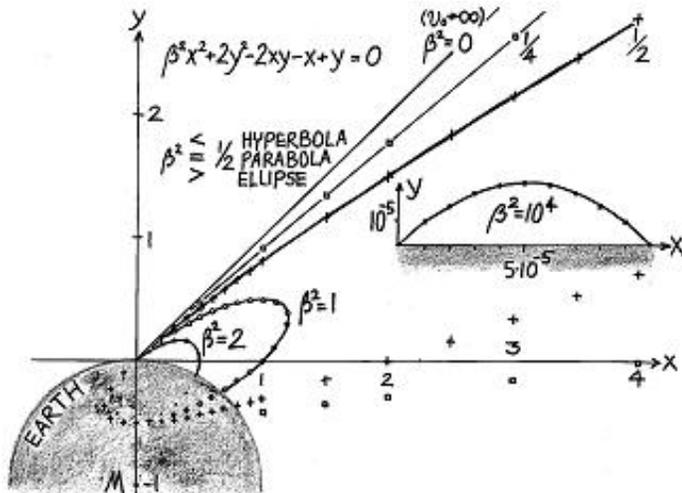


Fig. 1. Various paths depending on the ratio β . Solid lines indicate the physically relevant parts ("above ground"). Nice cone sections, but still not the solution to the problem. The cannon is at the origin and all paths pass through it and through $-R/2$ below. The x and y axis are normalized (units of R). The insert shows the ellipse for a more practical case with $\beta = 100$, where our flat Earth approximation for $g(y)$ holds. Here, the ellipse can be readily compared with that of the parabola treatment - both curves practically coincide. So, why should we bother? Simple and important: Because a "correct" result is not sufficient to prove a theory right!

We should be happy now - our result looks fine for all β . All β ? Mathematically, maybe. But it fails to be as consistent as we'd like it to be for physics, even if all those tacit assumptions were fulfilled: No air resistance, homogeneous distribution of M producing the same external gravitation field as if M were concentrated in the center, non-rotating Earth, strict two-body problem, ballistic constant initial velocity, undisturbed superposition of $x(t)$ and $y(t)$, etc. In fact, we have left the path of physics although our math seems to tell us that everything is OK. Can you see why and where? We leave that cute problem here which offers still more surprises. It was intended just to demonstrate how easy mainstream swimmers go past an inconsistency (an obvious and old one, too) that is worth considering. At least we can close the case of the low-velocity path: It is definitely elliptic. We can't blame Galileo for the erroneous parabola; he did not know about energy and gravity the way we do. Numerically, the parabola may be satisfying - the physics behind it is definitely wrong. Note - math is a helpful companion of physics in lucky instances - no less and no more. Math is a master science when it comes to precision - but it cannot replace precision in physics.

4. Precision, Please!

We are used to ambiguities of our everyday language and can fairly well handle them because the context helps us single out meanings that don't fit. "Writing or reading a book" provoke different understandings of the same word. In science (especially physics) it has become customary to lose the context out of sight. Without context, we are lost. Take an all-important issue: Energy, the "backbone of physics" is a relation that can only be defined in terms of a context. It is a contradiction in terms to isolate an object and speak about its "self energy". No interactions - no way to properly handle energy. The inconsiderate singling out an arbitrary part of an interacting system, then neglecting everything else and making the skeletonized scenario the basis of a natural principle has become a fatal habit in various disciplines of physics - not only those the 20th century brought forward. True, we can't possibly handle the complexity of the natural world, but we should realize what we must neglect and the consequences in doing so. Precision is demanded everywhere - respecting correct dimensions, bookkeeping of conditions or assumptions in experiment or theory, respectively, etc. Wherever inconsistencies are overlooked and whenever a case in physics gets a premature "closed" label we have to get back to precision. The premature labels seem to be evenly distributed over all disciplines of physics.

The above dogma of the parabolic path and its "improved" treatment is a beautiful lesson not to trust a result just because it looks nice. If engineers did their calculation jobs like so many we find in physics textbooks, would you trust their constructions?

The following appetizers to start (or continue) a career as upstream swimmer demonstrate that the river of science demands a lot if efforts no matter how smooth it might be flowing. It is mandatory to keep an eye on those easily overlooked.

5. Conditions, Conditions!

"The path of an object thrown at an angle in earth's gravity field is a parabola." This and all other premature statements remain meaningless unless the conditions are formulated under which they are assumed to be valid. The conditions are inseparably tied to the context.

6. Context!

Interactions are ubiquitous and they practically forbid to arbitrarily isolate parts from the context of a complex system. Since Newton's third axiom (actio = reactio; in fact an early aspect of energy conservation), it is accepted that action works mutually. There is always a two-way influence between interacting partners. For simplicity, usually one of the partners is considered as passive. (In some cases, this works quite well, see our above example: A little object (mass m) in the presence of a large object (mass M) feels the gradient of the gravity field due to M while M is not influenced at all. No need to consider two gravity potentials here.) Interactions are the trademark of any physical system and energy is the backbone of physics. If there ever was a breakthrough in physics deserving that name it's the discovery of the iron Principle of Energy Conservation (PEC). Strangely enough, energy is a late comer in physics (Thomas Young and William Rankine are credited for introducing and clarifying the concept of

energy) - much later than force. Energy, as a conserved quantity, plays the more fundamental role than force. The PEC with necessity requires the context as all-important condition. Energy is an abstraction as general as can be - it comes in many different disguises. Their interchanging may be formulated in terms of generalized potentials. Our above parameter β gives a clue: If we include velocity-squared potentials we have access to a wide class of interactions not considered in static scenarios. Now all changing velocities contribute to a wide variety of potentials helping to formulate interactions. And they are a great help in attacking dogmas. One of them is...

7. The Dogma of the Analytical Potential

We sometimes read "only conservative forces have a potential". This shouldn't be taken as a principle. What compels us to accept potentials only that can be presented in analytical form? We may safely state that most potentials are not analytical. If it can't be calculated, that doesn't mean it doesn't exist. Likewise, it has become a bad habit to discard of constant potentials as irrelevant and make them an arbitrary zero. No! Constant potentials play an important role on physics (see below). It's all too easy to put a quantity equal to zero. *Maxwell's* equations are a famous example.

8. The Maxwell Dogma

Neglecting the context has become a fatal practice in classical physics, too.

Take *Maxwell's* equations. Their success is undisputed, but it's due to the benevolence of a purely mathematical treatment lucky enough to fit the experimental situation rather than to consistent physics. "Electromagnetic waves" are obtained dismissing their sources - *charges* and *currents*. But all experiments are performed in the presence (or vicinity) of charges - the undisputed charges in our emitters (senders) and detectors (receivers). What entitles us to assume that there "are no charges in deep space" and at the same time allow their **E** and **B** fields to propagate? If there were sufficiently many charges in deep space to pass on **E** and **B** fields, that point would go to the friends of the Electric Universe. If not, the photon people get that point. We have to work with what our charge-containing detectors get and what we call "radiation". What can we tell about radiation in deep space under the conditions given? The photon interpretation is not only for charge-free deep space - it is our ticket to a famous effect in the vicinity of charges, too: The *photoelectric effect* whose naïve treatment won its author his Nobel Prize and burdened physics with the...

9. Single-Photon Dogma

"One photon in - one electron out" is the officially accepted balance for the photoelectric effect, historically the first performance of *Planck's* constant \hbar on the stage of physics after it left the cradle of quantum physics, the radiation law. In order to employ \hbar and make it a "quantum of energy" (of course, not energy is quantized, but action), the single photon had to be gifted with a strange property that, strangely enough, was readily accepted: An intrinsic frequency out of a huge reservoir covering many decades. Once accepted, this frequency nourished the belief that a single particle represents a wave, too, consisting of

"partial waves" if needed for mathematical reasons. This imported the "wave-particle dualism", a fatal because far-reaching dogma of its own. Nothing in *Planck's* radiation law compels us to maintain it is formulated for statistically independent *single* photons. It does not demand to endow the single photon with a frequency, a wavelength and a phase velocity. Keeping those as what they are, *wave parameters*, we arrive at a different picture: Photons are emitted in *coherent bunches* by all kinds of sources, their coherence length increasing as we pass from thermal source to laser. Now we are in a position to stay in the wave picture without having to revert to mathematical tricks. The frequency is the *arrival rate* of successive photons bound in a bunch, governed by their mutual distance (quite independent of the coherence length) and the concept of the wavelength applies to the periodicity within the bunch. Now it is even thinkable that all photons are identical. It is their rate of arrival which makes the difference in their effect. This is in accordance with the idea that potentials may respond dynamically and change under attack and need some specific duration to recover (see tunneling). The correspondence between attack rate and recovery duration now is a decisive parameter.

With photons travelling in bunches instead of independent individuals, we avoid the dualism dogma, but still have to give a thought (not answer!) to the question what their phase speed refers to. It is, by the way, similar to the question what the phase speed of sound refers to, say, in a gas. Certainly none of the atoms! But can void between them serve as a physical reference?

10. The Dogma of the Perfect Void

This is an ongoing tug-of-war: What is the "background" of the universe, aka light carrying medium? We have a good collection of models, gaseous, liquid, solid, nothingness - all tickets to the "ether hassle". Since the advent of special relativity with its premature interpretation of the MM null result (see below), the absence of anything (the dogma of the perfect void) in free space seems to be the official winner in this hassle. That dogma roots back to another dogma (see next section). What could be an upstream swimmer's view here? The c^2 potential makes another nice pet idea of a "potentially" consistent approach to the ongoing ether hassle. Of course, our c^2 does not explain anything. That's not its aim. Trying to "explain" might stop us thinking. Our pet idea gives us possibilities to keep on thinking, relating that idea to other problems, like the occurrence of c^2 terms in neomechanics ($E = mc^2$!) and the ultimate speed.

11. The Dogma of the Ultimate Observer-Related Speed

The most famous velocity-squared term is c^2 . It occurs in many places in physics and has been misused by a theory that gave no thought about the role of c^2 and has no right to talk about a limiting speed c because it denies uniqueness. If we manage to work consistently with the c^2 potential, we need not worry about its origin (like nobody ever worries about the origin of mass or energy). It may (may!) prove to be consistent that c^2 originates as the constant average from all the gravitational fields

contributed by all the masses in the infinite Universe. Such a system characterized by an ensemble parameter is known as an effective medium (consider e.g. the density of a gas that plays a role for the speed of sound). We take c^2 as constant here. That makes $E = mc^2$ a static relationship - it is the rock-bottom energy of an object m at rest (a physical state requiring a *unique* reference!) in a region of *constant* (not zero!) potential c^2 . We may introduce dynamics now with a function $\gamma(v)$ to be determined from energy principles. We require v to be unique ("absolute"). Then the "total" (total for this simple scenario, that is) energy of m becomes $E = mc^2\gamma(v)$. When motion comes into play, we deal with kinetic energy and momentum. The theorem of kinetic energy reads $dE = \mathbf{v} \cdot d\mathbf{p}$ which we equate to $dE = mc^2 d\gamma$. Considering that dE is proportional to both $d\gamma$ and $d\mathbf{p}$ suggests the ansatz $\mathbf{p} = m\gamma\mathbf{v}$. Now we have everything to arrive at $\gamma = 1/\sqrt{1 - v^2/c^2}$ in a few elementary steps, cancelling m again, using $\gamma(0) = 1$ as boundary condition.

Looks familiar, doesn't it? But: No transformations here, just solid energy and unique velocity potentials!

Our γ has nothing to do with special relativity, in spite of the striking similarity. (At times math is a master fooler!) The denial of a unique reference, material or non-material, left special relativity with the wrong conclusion that the observers only make a legitimate reference. High speed physics referring to absolute space therefore should be called *neomechanics* for distinction. Neomechanics takes into account the dynamic context and the idea that any travelling object acts on its surrounding c^2 potential. Now it's not the mass that all by itself diverges as its speed approaches c - the changing $\gamma(v)c^2$ reacts on m , which can safely be taken as constant without affecting the result.

The symbols in $E = mc^2\gamma(v)$ have no meaning unless their context is specified. Ironically, they made a career as an isolated statement, but they are no more surprising than the low-speed approximation of kinetic energy, $E = mv^2/2$.

The speed of light is by no means observer-related. This leads us to the...

12. Michelson-Morley Dogma

This famous brilliant experiment suffered (and still does) from many fruitless discussions and its outcome was a headache (not only) for *Michelson* and *Morley*. The fatal dogma of this deal here is the premature denial of a preferred reference for the propagation of light, giving all moving (!) observers the status of a legal reference, nourishing the dogma of all (invented!) coordinate systems being equivalent "inertial systems". Our above unique γ factor gives us confidence to exclaim...

13. Uniqueness Is It!

Ever since scientists were convinced about *energy conservation*, they *should* have adopted the idea of a unique physical system - the Universe as a whole. It provides the only consistent (in more than one sense!) reference. What we call inertia is another expression for energy conservation. The latter is a global principle (that

approximately holds for fairly "closed" subsystems, i.e. in the absence of radiation, etc.) In consequence, the Universe provides the one and only inertial system. All those invented kinematic systems in uniform unidirectional motion have nothing to do with energy conservation. (It does make a difference whether the train is moving or the station!)

We cannot do without a reference. Taking "absolute" as contrast to "relative" misses that point. The PEC suggests to use "absolute" in the sense of "unique". Absolute velocities refer to the universe as a whole ("absolute space"). There is nothing strange about a non-material system of reference - we are used to the non-material "center of mass" of a ring-shaped object. The velocity of light is tied to (and governed by?) the one and only inertial system. Relative velocities (a matter of kinematics, not dynamics!) are best defined as differences between absolute velocities.

14. Back to the MM Experiment: Null Result or Non-zero Fringe Shift?

Uniqueness helps us to analyze the behavior of the interference pattern (here is where waves play their part) in terms of the *Doppler* effect in absolute space. That may look strange to people who tie c either to the observer (as relativists do) or to the source (as *Ritz'* followers do). Both assumptions with their many different velocities of light lead to inconsistencies. The *Doppler* effect with the observer co-moving with the source may look somewhat strange, too. Of course, the co-moving observer does not notice the effect (zero relative velocity!). But that does not mean it does not exist. It makes a difference whether source ($v_s \neq 0$) or observer ($v_0 \neq 0$) is moving, both being absolute velocities. It is important to refer all velocities involved (including c) to a unique system. Meet another dogma here - the dogma of the equivalence of all "inertial systems" whether moving or not. In absolute space the state of rest is unique and therefore not "equivalent" with any moving system. In the $v_s \neq 0$ case the wavelengths are Doppler-shifted, contracting ahead (meet yet another dogma - the *Lorentz* contraction of solid bars instead of light(!) wavelengths) because the waves cannot outrun the source at c . The total number of the out-and-back paths turns out to be changed by the *isotropic* factor...

$1 - v_s^2/c^2$, i.e. no change of interference pattern when the set-up is rotated. However, the pattern may change when the component \mathbf{v} of the absolute velocity (the sum of a cosmic, an orbital, and earth's rotational part) in the plane of the experiment and hence...

$1 - v^2/c^2$ is allowed to change. This may happen observing the pattern with a fixed set-up and waiting till the absolute motion of the lab does the job. The result depends on the experimental condition.

The *Sagnac* experiment (which will see its 100th anniversary in 2013) is another striking example for a unique reference. It is a headache to all relativists, whether they admit it or not - another good point for naming the NPA Award after *Georges Marc Marie Sagnac*, who was a fervent opponent to special relativity!

Special relativity is not the only dogmatic theory that gives the observer a fundamental role. Even more fatal than the inertial system dogma is...

15. The Uncertainty Dogma

The cradle of *Planck's* constant \hbar was a formula that coherently described thermal radiation ("light" for short) over a wide range of frequencies. Light seems to be the most striking yet common phenomenon in the Universe – ubiquitous and fast.

Energy should not be confused with action. *Quantization* refers to action (*Planck's* constant!), not energy. Action has two ingredients – a local change of energy ΔE and its duration $\Delta \tau$ making a product $\Delta E \Delta \tau$. Nothing here is tied to our "knowledge" – Nature always acted Her way - before She invented observers! (That observation is an interactive process and shows its traces particularly on the atomic scale is rather trivial.) The dogma of uncertainty fails to give an answer why there should be a minimum $\Delta E \Delta \tau$. Being a dogma, it stops our thinking. Let's invest, with due caution, our detective work somewhere else (Fig. 2).

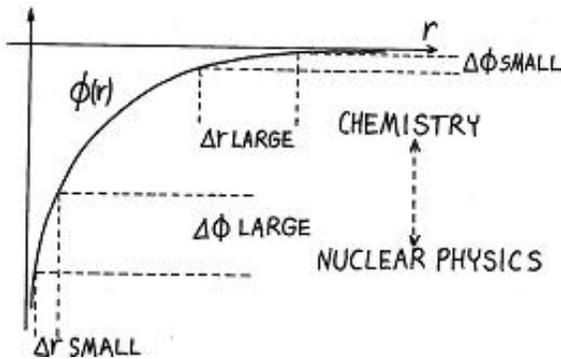


Fig. 2. Do potentials $\Phi(r)$ have a built-in mechanism for quantization? Consider two regions of different slopes of any kind of potential depending on distance in the characteristic fashion sketched, not necessarily an analytical potential. The difference in energy is proportional to $\Delta\Phi$ and the duration $\Delta\tau$ to cover the corresponding distances Δr gets shorter as gradients get steeper. We are familiar with this: Large energies are released quickly from their sources (dynamite), whereas low energies are delivered slowly (food) as symbolized by the limits "nuclear physics" and "chemistry". We would expect a natural lower (non-zero) limit for $\Delta E \Delta \tau$ if that product were constant with potentials tying the two factors together. Speculative? Maybe, but certainly less speculative than "uncertainty".

Of course, the $\Phi(r)$ need not be static. In general, they wouldn't be. Which brings us to...

16. The Tunneling Dogma

The usual idea of escape from a potential barrier is that it works on a temporary violation of the PEC. Why should it? Why should the confining potential stay unchanged in the process? It is more consistent with Newton's Third Principle to consider the influence of the escaping particle on its confining barrier: The barrier changes under repeated attacks until it gives in if it can't recover quickly enough. This is quite familiar: The battering ram eventually destroys the castle's door; the main difference being that the door can't recover from the changes while atomic potentials can unless the rate of attack becomes too great. Another well-known example is fatigue: If you bend a piece of wire in alternating successions, it will eventually break. You did not have to provide the force needed to tear it apart; you did it by permanent weakening of the potentials binding the metal atoms together – nothing short of a true tunneling process!

More dogmas to chew on? You'll find plenty!

17. Dogmas Galore!

Looking into your textbooks, you can easily fill your own grab bag of dogmas in physics.

The above "down to earth" example of the oblique throw teaches us to keep physical analysis in mind, no matter how tempting the mathematical outcome and no matter how "classical" the problem. The more sophisticated the math, the more it camouflages the dogma. No matter whether we have to tackle the Big Bang, the Copenhagen School of Quantum Theory, the two Relativities, questionable mathematical formalisms, etc., etc..., we have to get rid of the grip of dogmas in physics, especially those that fake "correct" answers. We can't blame the pioneers of what later became a dogma (they once were upstream swimmers, themselves), but their epigones who failed to do the job of testing and, if needed, correcting or dismissing premature labels in physics, thus making them a dogma.

How to recognize a dogma? A dogma has to be protected by heavy propaganda to survive. The German philosopher *Ludwig Feuerbach* (1804–1872) gives the definite answer: "A dogma is the outspoken forbiddance to do some thinking" [my translation].

Thinking is a non-stop challenge - that's what makes science the paradise of thinking!