The Planck scale in the light of psychological enquiry

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❧ IN MEMORIAM ❧
GARRETT JAMES HARDIN (1915–2003)

The progress of science — indeed of all positive knowledge — depends on the courage of Thoreau's "majority of one" in the face of nearly unanimous error.

NAKED EMPERORS: ESSAYS OF A TABOO STALKER (1982)

☛ A psychological enquiry into the Planck scale in quantum gravity, as guided by the application of Garrett Hardin's three filters against folly: literacy (what are the words?), numeracy (what are the numbers?), and ecolacy (and then, what?).

1 A Martian view

THE EMERGING HISTORY of quantum gravity is a story of confusion and denial — confusion experienced, but confusion psychologically denied in our innermost being. Orphaned, lacking a model in the real world, a natural referent that it can be *about*, and thus unable to escape decade upon decade of disorientation and frustration, quantum gravity has welcomed and nurtured the Planck scale as its saving grace. The Planck scale has provided quantum gravity, as a whole and beyond particular approach, an essential and much-needed handle for it to grab onto in an otherwise phenomenologically barren and unsignposted field of theoretical research.

For another history in similar, or direr, straits, see (Hardin, 1969, p. vii).

As the Planck scale gathers stature and esteem in frontier physics with temerarious rapidity, the alert, inquisitive mind nonetheless finds the notion poignantly intriguing. It is stimulated at once, inescapably drawn to delve into the underlying reason of being of this notion with the detachment of

Adam Smith's impartial spectator; of Hans Reichenbach's (1951) neutral observer, who investigates strange ideas "as the naturalist studies a rare specimen of beetle" (p. 3); or of Ernest Renan's — and Garrett Hardin's (1972, p. 72) favourite — unprejudiced man from Mars.

(Meschini, 2007) In a previous enquiry, we looked into the dimensional-analytic origins of the Planck scale as used presently in quantum gravity, and found its relevance to physics to be dubious. The purpose of the present investigation is to press on with an analysis beyond the what and the how of this arresting notion — questions pertaining to the sphere of purely physical enquiry. It is now time to dig deeper into the heart of this notion and ask not, "What is the Planck scale?" but rather, "*Why* is the Planck scale?"

In other words: to ponder the Planck scale in the light of psychological enquiry.

2 Filters against folly

Biologist-ecologist Garrett J. Hardin was a man cursed with the painful burden of acute, prophetical vision and blessed with the gift of emotive, rhetoric-free, uncompromising exposition. Grasping, unfettered, the burning nettles of population and progress taboos, in *Filters against folly* Hardin gave us a set of three different filters, tools of thought by means of which we may better assay humanity's mounting ecological woes. All three filters would be applied together, as the bias of each filter is compensated for by those of the others.

The first filter is *literacy*; the paradigm of its application in the investigation of some matter is the question, "*What are the words?*" As Hardin (1985) put it — with a simplicity sure to astound any long-time scholar of Sapir and Whorf — "Beyond communication, language has two functions: to promote thought, and to prevent it" (p. 28). In consequence, asking about the words of an issue can both show that the current ones are thought-restrictive and not entirely suitable, and help us find better ones that will free our minds and afford us broader vision.

The second filter is *numeracy*; it is applied by asking the question, "*What are the numbers?*" This filter is devised to draw our attention to the quantitative aspect of matters, in addition to the qualitative aspect grasped by the literacy filter. The numeracy filter requires that, once disclosed, we shall proceed to interpret the relevant numbers wisely in the light of available knowledge.

The third and last filter is *ecolacy*. It is the deepest-reaching filter of the three. Its penetrating power resides in its unconventional approach, for it forces us to view matters in a way we are not accustomed to. In the pursuit of immediate satisfaction, in current society we all too often approach life and the circumstances it presents with a short-term attitude: we want things, and we want them now — tomorrow at the latest. The ecolacy filter forces us to take a long-term perspective. After all is said and hopefully not yet done, we proceed to ask the awkward question, *"And then, what?"*

In ecology, this is a perspective of the order of centuries; in everyday life, of the order of decades.

Hardin's filters not only are filters against the folly of policymakers in a constantly growing, yet paradoxically finite and already overpopulated world. They are filters against folly also in other fields of enquiry.

What do these filters reveal when we apply them to the idea of the Planck scale in the field of quantum gravity?

3 What are the words?

The Planck scale is characterized by the Planck length l_P, the Planck time t_P, and the Planck mass m_P (or the Planck energy E_P). The words to pass through the literacy filter are, therefore, "length," "time," and "mass" (or "energy"). If these are the foundational concepts of quantum gravity, what qualitative kind of theory does one expect to build upon them?

From the joint consideration of these concepts, quantum gravity emerges as an essentially *mechanical theory* of something physical, but for the moment unknown (seemingly only a circumstantial aside), of a certain typical size l_P and mass m_P (or energy E_P) evolving in time in typical periods t_P.

But judging from the grand revisionist prospects that typically characterize this field of research — visions that, we hear, involve revolutionary changes in our ideas of space and time — length, time, and mass as foundational concepts fall badly short of the mark. How can a mechanical theory of something whatever provide insight into the very concepts it needs to assume without question or analysis? If, say, a string of length l, mass m, and vibrational energy E in (some) space evolves dynamically in parameter time t, how could any hypothetical theory of strings uncover a deeper layer of the nature of these ideas? Mechanics is built upon space, parameter time, and mass; it uses them, thinks on them, rides on their backs, but it does not and cannot explain them.

This state of affairs has been acknowledged by David Gross, in a *Nova* interview, in the following revealing words:

> We've replaced particles with strings — that in a sense is the most revolutionary aspect of the theory. But all of the other concepts of physics have been *left untouched*. . . .
>
> On the other hand, many of us believe that that will be insufficient to realize the final goals of string theory, or even to truly understand what the theory is, what its basic principles are. That at some point, a much more drastic *revolution* or discontinuity in our system of beliefs will be *required*. And that this revolution will likely change the way we think about space and time, maybe even eliminate them completely as a basis for our description of reality.

As Gross seems to acknowledge, calling a replacement of point-particles with strings a revolution does not seem entirely appropriate. We instead gather from his words that string theory is not the awaited revolution but that *it needs* a revolution. But again, how could a revolution grow on top of mechanical strings in space and parameter time when it is this mechanical edifice itself that wants deeper foundations? Shall we fit the enigmas of space, time, and matter to the geometrico-mechanical methods handed down to us by history — developed and used for tackling *other* problems — or shall we devise methods suited to the different enigmas that today confront us? Shall we fit the hand to the glove, or the glove to the hand? We listen to José Ortega y Gasset:

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> What's the sense of this? Science must solve its problems today, not transfer them *ad kalendas Græcas*. If its present methods do not suffice to master today the enigmas of the universe, the discreet thing to do is to substitute these with more efficient ones. But science as used is full of problems that are left intact due to being incompatible with its methods. As though the problems were forced to comply with the methods, and not the other way around![a] (Ortega y Gasset, 1923, p. 162)

Besides length, time, and mass, the occasional extra consideration of a Planck charge q_P, obtained using the permittivity of vacuum ϵ_0, and of a Planck temperature τ_P, obtained using Boltzmann's constant k_B, does not afford much assistance from this perspective either, as quantum gravity could then be an electrodynamic, thermodynamic, or electro-thermodynamic theory based on a wider range of concepts that still remain unexamined and unexaminable. More is not better. In fact, the opposite holds in scientific theorizing, where, as a rule, small is beautiful.

To make matters worse, like the choice of (constants leading to) the basic Planck scale, the choice of an extended Planck scale is likewise left to the observationally unguided taste of the theorist. For example, on what basis shall he choose an extra natural constant whose dimensions contain the Coulomb unit and is thus apt to produce the Planck charge? The normal choice is the permittivity of vacuum ϵ_0, but why should not the electron charge e be already the relevant Planck charge he seeks? And similarly but more worryingly: why should not the electron (or proton, or neutron, or quark) radius, $l = 10^{-15}$ m, be already the relevant Planck length he seeks? Because the word "electron" does not look like the word "Planck"? Or because the application of dimensional analysis is not necessary to obtain it?

The permeability of vacuum μ_0 leads to the same result.

From the words "length," "time," and "mass," we then draw the conclusion that a Planck-scale theory of quantum gravity — by and large, the only type in existence — is a mechanical theory that cannot begin to clarify the concepts that inspire its study: it can think *in terms of* them, but it cannot think *about* them. "What are space and time?" Magnificent and awe-inspiring resounds the question in lecture halls and fills the pages of thick scholarly volumes only for its echo to return, endless, unperturbed, and void, to haunt us.

We have here at hand an especially significant example of what Ortega y Gasset (1934) has called beliefs we live by, as opposed to ideas we have. That is to say: in order to understand physical conceptions anew, we need to have fresh ideas about them, but because the very conceptions that we now examine function within us as our normal categories of thought, as the unperceived, unquestioned background on which our intellectual activity takes place, thinking fresh thoughts about them requires that we shall first proceed to question them. But how shall we do so, when escaping precisely our beliefs in space, time, and matter is so strenuous and exhausting, for virtually *all* background for thought is lost, that we relapse and fail to think new thoughts about them even as we *explicitly, purposefully, and continually*, with an emphasis updated by the minute, set out to do so? Here, unlike lesser beliefs which we can question as soon as the matter is brought to our attention (e.g. the firmness of the ground beneath our feet), we are confronted by beliefs so deep-rooted that, without them, the intellect goes blind and becomes paralysed with the terror of sudden, pitch-black darkness: to see anything at all, the flame of the original beliefs is desperately needed.

Note, furthermore, that within this elemental trio of beliefs — space, time, matter — it is time that is rooted deepest. Time is, in fact, the deepest-rooted of all beliefs we live by. The belief that there was a past, there is a present, and there will be a future guides our every utterance, action, and thought. Accordingly, no other belief is placed under a taboo more stringent than time is: time is the first belief, the last taboo. To illustrate the point, consider: frontier physics offers varied new ways of looking at space (a wrapped-up multidimensional manifold, a graph, a network, a lattice, a causal set, a "foam"), but time is everywhere we look the same external parameter, t, on which we simplemindedly project our beliefs of past, present, and future. Physicists are wont to talk about eliminating time from our description of reality, and yet no genuinely "timeless" new description is anywhere to be seen. And no wonder. Time and time alone is inextricably linked with the fact that we are, with our conscious being; and so, Borges's (1947, p. 277) metaphor, "Time is the substance I am made of," is perhaps more than just a metaphor.

With this, we have a first approach to the matter. But to understand why we have come to the Planck scale, we must take the enquiry further.

Traditionally, the key in the development of new and better scientific theories has always been laboratory experiments, field work, and observations of the surrounding world. The history of science is a felicitous testimony to this assertion: Galilei dropped weights; Newton span water buckets; Hutton took notice of erosion processes in his farmland by "looking with anxious curiosity into every pit or ditch or bed of a river that fell in my way;" Darwin picked beetles, bones, and stones; Faraday passed currents through wires;

Einstein rode, stopwatch in hand, dreamtrains towards lightrays, and felt in his bones what it feels like falling; Planck looked into a black box of light; and Bohr into the spectra of rarefied matter.

It may be here added parenthetically that Einstein, unlike most men of science before him, did not base himself on the results of actual experiments to invent the general theory of relativity. (For the special theory, he based himself on the experimental observation of the constancy of the speed of light.) Yet, his method was far from rationalist-deductive, for, unlike today's frontier physicists, he sought and found inspiration in simple thought experiments that were *about the real world* in a down-to-earth manner: Einstein's thought experiments were about rods and clocks, lightrays and trains, men in free fall and gravitation — not concocted out of strings, minuscule black holes, and foams, the referents of which no-one's ever seen. Unlike Galilei and others, Einstein did not get his hands dirty, but his method closely amounted to an empirical one all the same. Nevertheless, as López Corredoira (2005) has observed, Einstein's method is nowadays perceived as rationalist-deductive, as truth emanated from the crystal ball of pure thought, and inspiration for such a new way of doing physics is being mistakenly, fatally, drawn from it by Einstein's epigones.

Are there not also now phenomena we want to understand, anew or for the first time, and on which the invention of quantum-gravity theories is or may be based? There certainly are, for mysteries no doubt abound: the redshift of galaxies, the interference of matter through two slits (i.e. the phenomenon of existence), the conscious feeling of time and its relation to clocks, the quality of conscious experience, life, etc. But quantum gravity differs from ventures past, because these and other enigmas do not lead to or call for the Planck scale as their explanation. On the contrary, the Planck scale has an origin prior to and independent of any natural enigmas it may desire to throw light upon: quantum gravity builds its building upside down, with the chimney in the cellar, or its carriage backwards, with the phenomenological horse being pulled by the theoretical cart.

Eschewing frontier physics the kind of inspiration and guidance abundant in the pathways of its tradition, the Planck scale is instead reached by looking at the *words* "quantum gravity," and drawing from them the superficial suggestion that the natural constants h (quantum), G (gravitation), and c (relativity) must figure centre-stage; and it is subsequently welcomed because their dimensions generously combine to produce a typical length, time, and mass. These are the most easily malleable conceptions for theory construction due to their immeasurable qualitative appeal to the above-mentioned background of beliefs we live by, to the unexamined *human psyche*, which by nature possesses a stronger affinity with easily visualizable (i.e. geometric) mechanical concepts to the detriment of other ideas farther removed from this sphere. Length, time, and mass are, in short, the Plasticine of the human psyche, and here is partly why, despite its humble origins (about which more later), the Planck scale is offered such a welcoming parade. Given thus the Planck scale, it is accepted once and for all, and it is then violently superimposed on any, enigmatic or not, phenomena, which, like the disesteemed horse, are forced to adjust to the blind pull of the cart of their preconceived explanation. As a result, phenomena are *in practice* irrelevant to theory construction.

Now, why should a mechanical theory be so psychologically pleasing? The human study of nature starts with the attempt to picture the most elemental phenomenon in consciousness, namely, change. Change finds its primitive expression in two different forms: externally to consciousness, as motion (the motion of things); and internally to consciousness, as the succession of feelings. From the perspective of human reason, these two forms of change are mutually dichotomous: the privately experienced world of inner thoughts and feelings eludes so far submission to the extreme rationalizations of physics — consciousness, as it were, refuses to disclose what it is made of — whence no physical theory of consciousness; but the public world of things in motion is, on the contrary, highly amenable to physical rationalization, opposing little resistance to the disclosure of its essence. We may say, inverting Hardin's figure, that the farther problems are, the easier. So amenable is, in fact, motion to the mind that the formation of man's physical world-picture naturally starts from mechanics: motion is the simplest phenomenon for humans to physically describe.

"As we withdraw our attention from the moon and focus it once more on problems in our back yard we inevitably discover that the nearer problems are the more difficult. The real difficulties . . . lie not in the stars but in ourselves." (Hardin, 1972, p. ix)

As a result of this psychological fact, a mechanical theory will appeal the most to, will be in the most finely tuned resonance with humans' basic instinct. It is therefore to be expected that, having denied any prior direction to be had from phenomena, the researcher will naturally come to rely *exclusively* on himself — the form of his current knowledge, his learnt methods of theorizing, his psychological needs (e.g. geometric visualization) — adapting his new theories purely to these. Hence the geometrico-mechanical Planck scale as a ready foundation for quantum gravity, that is to say, for theories by humans about nothing in particular.

By means of illustration, heed at this point the lesson offered us by quantum mechanics. Even though it was at first expected to build quantum mechanics as a mechanical theory in the primitive sense of the word (cf. Bohr's atom), it was precisely the mounting *observation* of quantum *phenomena* and their peculiarities that led *away* from the simple and expected mechanical theory in which microscopic particles too would behave deterministically, trace trajectories, or even exist in the usual sense of the word. The crude reality of these peculiar observations is solely accountable for the creative rise of quantum mechanics as it came to be, of a theory whose very name betrays the unfulfilled original preconceptions of its builders: what's most primitively mechanical about quantum mechanics is its name indeed! And to this day, quantum mechanics is *felt* to be a puzzle insofar as it is not mechanical.

Once again, Gross's words on the delicate state of string theory are apt to throw light on this strange state of affairs; his reflection continues as follows: "We have this incredibly powerful set of tools and methods that describe this *intellectual structure*, and yet we really don't know what lies at the core of that." This description of the theory being a set of tools, an intellectual structure, is again remarkably precise of the quantum-gravity situation: human intellectual structures are precisely what has been produced, clever frameworks to serve as our tools of thought — *but to think about what?*

No answer is forthcoming, and this is the source of the trouble. What lies at the core of string theory or, for that matter, of any other quantum-gravity theory? We now see that the reason behind this disorientation is rather simple: these theories did not spring from down-to-earth experience, and as we do not know what these theories are *about*, what their models are (what they attempt to "copy"), what they refer to in the natural world, what observed phenomena it is they are supposed to explain, so they remain clever pieces of abstract thought — rightful denizens of the pure mathematical realm — but fail to attain semantic meaning. In our heads alone do these intellectual structures, properly so called, live, while nature refuses to mirror back any light they attempt to throw upon it. Ultimately, confusion ensues because of our determination to yet take these theories all too seriously.

On the positive side, the application of the literacy filter still has more to offer. If "length," "time interval," and "mass" are not the words, what then *are* the words? The specific words are, naturally, unknown. But the direction in which we should look to find them is clear: observation of nature, accessible experiments that humans can modify and affect. The road to quantum gravity does not end nor start with disembodied mathematical concepts; it starts and ends with physical things we can observe and control. Any theory built on their basis *will* possess semantic meaning, *will* be about something, *will* have a model, *will* be physical. "Physical things" — *these* are the words.

"We are most interested when science reports what those men [who spend their lives in the fields and woods] already know practically or instinctively, for that alone is a true *humanity*, or account of human experience." (Thoreau, 1854, p. 261)

4 What are the numbers?

Although the useful application of the literacy filter is by no means easy, the layman normally feels at home only within the area of relevance of this more primitive filter. He does not feel at home weighing numbers, preferring to leave such tasks to the scientist. Scientists, on the other hand, are renowned for excelling in their use and understanding of numbers: relative sizes, rates of change, cumulative quantities, orders of magnitude, etc. are all part of their everyday tasks. Indeed, as Hardin (1961) has said, "Perhaps no single thought pattern distinguishes the scientist quite so clearly from the nonscientist as his habit of putting questions into quantitative form before seeking answers" (p. 19).

In this light, we would naively expect to find that, if not perhaps too well disposed for a literate analysis, physicists should at least succeed in drawing enlightenment from the application of the numerate filter to the Planck scale. The study of the physicist's failure of analysis also in this field — a field in which his intellect is so keen it is *too* keen — is apt to teach us more revealing lessons about his psyche.

For the layman, physicists' involvement with quantitative matters runs so much wider and deeper than any business he may have with numbers in his everyday life that those not well acquainted with physical science tend to believe that it is *all* about numbers. The physicist's love affair with numbers is in reality not as straightforward and simpleminded as this presumption has it, because physics is not a mindless display of equations and numbers (or letters), but about qualitative ideas and concepts — meaningful words, words with semantic meaning — about natural observations which, under favourable circumstances, which is in physics almost always, can *then* be quantified and handled accordingly. In this respect, the layman is wrong. Physics is much more than mere numbers. But there is a sense in which the layman is right, acutely right, as though his untrammelled intuition and detached perspective were grasping an aspect of truth that only intuition and an ignorance of the details can afford. How so?

In frontier physics, there reigns currently an undue emphasis on, metaphorically speaking, numbers. Having denied phenomena as a guide to physics' progress, there ensues a Narcissist intoxication with the grace and malleability of our own tools of thought; and in physics, these tools are embodied in — what charmingly fitting *etymos!* — the discipline of having the mind aroused, namely, mathematics. Hence the number metaphor. In practice and against the dicta of the physical tradition, mathematics for mathematics' sake, *concepts per se* as opposed to *concepts about,* become the order of the day. The conspicuous results of this enterprise are mere *quantitative technicalities*, deep and careful studies of quantitative mathematical detail so absorbing and consuming as to prevent any questions as to their underlying conceptual meaning against the background of human experience. As a result, the Planck-scale physicist's numerate analyses become void: empty technical intricacies of calculation, recalculation, and countercalculation; perfect semantic vacua where nature's fresh breeze does not blow, but where we must instead continually re-inhale our own stale exhalations, poisoning thus the blood of physical enquiry.

"Most men would feel insulted if it were proposed to employ them in throwing stones over a wall, and then in throwing them back, merely that they might earn their wages. But many are no more worthily employed now." (Thoreau, 1863, p. 356)

I hasten to add that the provocative phrase "quantitative technicalities" is not to mean that mathematically demanding quantitative analyses are superfluous or never needed in physics; on the contrary, they are usually essential to its progress and renewal. The present criticism is instead of quantitative technicalities for their own sake, of quantitative technicalities based on no observational foundation. Consider, for instance, the case of tensor analysis in general relativity, which is based on the physico-mathematical correspondence given by the quadratic form $\mathrm{d}s = [\epsilon g_{\alpha\beta}(x)\mathrm{d}x^\alpha \mathrm{d}x^\beta]^{1/2}$, where $\epsilon = \pm 1$:

on the physical side, on the left, we have ds, which is always a separation between two events measured directly with a clock; on the mathematical side, on the right, we have the metric tensor and the differential displacements, which link the observational raw material ds with the mathematical theoretical picture general relativity makes of it via the "quantitative technicality," now with a positive connotation, of differential geometry and tensor analysis.

$l_P = \sqrt{Gh/c^3}$, $t_P = \sqrt{Gh/c^5}$, $m_P = \sqrt{hc/G}$.

What are, then, the numbers to pass through the numerate filter? The numbers are $l_P = 4.05 \times 10^{-35}$ m, $t_P = 1.35 \times 10^{-43}$ s, and $m_P = 5.46 \times 10^{-8}$ kg (or $E_P = m_P c^2 = 4.90 \times 10^9$ J). If these are the numbers of quantum gravity's mechanical foundation, what quantitative kind of theory does one expect to build upon them?

All quantities to the nearest order of magnitude.

One is, first of all, led to the idea that the unknown mechanical object in question is of the order of $l_P = 10^{-35}$ m long. Or that, if not line-like but rather more like a surface or a solid, its area is $l_P^2 = 10^{-69}$ m^2 or its volume $l_P^3 = 10^{-103}$ m^3. Secondly, one is led to a picture in which this very small mechanical something evolves in time, that is, changes its state (some of its unknown properties acquire significantly new values) as often as about once every $t_P = 10^{-43}$ s. Perhaps, this being a quantum-mechanical theory, this typical period could even picture the discrete temporal evolution of the said mechanical object, in that its states do not evolve continuously but by jumps. Thirdly, this very small and very active mechanical object has a mass of the order of $m_P = 10^{-7}$ kg, which means that, for a solid-like object, its mass density is $m_P/l_P^3 = 10^{96}$ kg/m^3. Finally, given the uncertainty about its physical nature, were the massive object in question akin to known matter, it may also be considered to possess a rest energy of the order of $E_P = m_P c^2 = 10^9$ J, with an energy density of about $E_P/l_P^3 = 10^{113}$ J/m^3.

These simpleminded expectations are not disappointed when we look at the quantitative mechanics so far outlined by the quantum-gravity physicist. In his theories, the mechanical object above takes an endless variety of forms and goes by as many names: (i) string, loop, edge (of a graph, of a causal set, of a lattice, of a network), (ii) membrane, spin-network surface (quantized area and volume), and (iii) spin network, spin foam, Planck black hole, etc., tellingly exhausting the three possibilities of line-, surface-, and solid-like objects, or generalizations to $n \lesssim 11$ dimensions thereof, within the geometrico-mechanical boundaries of the possible.

Now, what kind of values are these within the context of current physics? How do they compare with existing human knowledge?

The smallest natural objects known are the elementary constituents of matter: electrons, protons, neutrons, and quarks. All of these have a size of the order of 10^{-15} m, insofar as it remains meaningful to speak of their size at all. And the smallest humanly measurable distance is of the order of attometres, i.e. 10^{-18} m, claimed measurable at the Laser Interferometer Gravitational-Wave Observatory via the interference of light between the

	known	Planck	comparison (Planck/known)
length (m)	10^{-18}	10^{-35}	$10^{-17} = \frac{\text{human arm (1 m)}}{\text{to Proxima Centauri (4 ly)}}$
time (s)	10^{-28}	10^{-43}	$10^{-15} = \frac{\text{blink of an eye (0.1 s)}}{\text{since Australopithecus (4 My)}}$
energy (J)	10^{-6}	10^{9}	$10^{15} = \frac{\text{world ann. extraction (400 TJ)}}{\text{coin, 1-m rise (0.1 J)}}$
mass density (kg/m³)	10^{18}	10^{96}	$10^{78} =$?
energy density (J/m³)	10^{35}	10^{113}	$10^{78} =$?

Table 1: A comparison between the sizes, to the nearest order of magnitude, of the smallest or largest scale of natural phenomena currently known and those of the Planck scale. For each physical magnitude, a dismal chasm of at least a dozen orders of magnitude needs to be bridged before direct observation of hypothetical phenomena at the Planck scale may be rendered meaningful. For instance, the Planck length is to a human, who cannot detect anything smaller than 10^{-18} m, as a human arm (1 m) is to a being who cannot detect anything smaller than the distance between the sun and Proxima Centauri (4 ly). In the last two rows, the Planck quantities involved are so colossal that it is not possible to produce the called-for comparison. For example, the densest known thing, a neutron star (10^{18} kg/m^3), and the least dense known thing, the intergalactic vacuum (10^{-27} kg/m^3), are not dense and ethereal enough for the task, giving: neutron-star density/intergalactic-vacuum density $= 10^{45} \ll 10^{78}$. This unworldly are the mass and energy densities (2nd column, 4th & 5th rows) of the purported Planck black hole.

mirrors at the far ends of two long material arms.

The shortest-lasting event known is the periodic vibration of high-frequency gamma radiation from the Cygnus region of the galaxy; these are time intervals of the order of 10^{-28} s (frequencies of about 10^{27} Hz). Other known very short-lasting events are the mean lifetimes of the W and Z bosons, which are of the order of 10^{-24} s.

The densest natural objects known are neutron stars, with maximum mass densities of the order of 10^{18} kg/m^3, and atomic nuclei, with mass densities of the order of 10^{17} kg/m^3. The rest energy density of these natural objects is then of the order of 10^{35} J/m^3 and 10^{34} J/m^3, respectively. In terms of the energy carried by a probing elementary particle — these are the sharpest and most powerful cutting tools humanly available — the highest energies so far achieved, or claimed achievable, are of the order of 10^{-7} J (2 TeV) at the Tevatron facility and 10^{-6} J (14 TeV) at the Large Hadron Collider.

It becomes apparent that direct accessibility of hypothetical phenomena at the Planck scale compares dismally with the present state of human knowledge and know-how (Table 1). Gigantic chasms of 17 orders of magnitude of length, 15 orders of magnitude of time intervals and of energy, and 78 orders of magnitude of mass density or energy density need to be bridged before direct observation of Planck-scale phenomena can be rendered meaningful.

Physics consists in the human attempt to elucidate the how and why of elemental natural phenomena. What natural phenomena does man attempt to elucidate by means of a theoretical picture in which these minuscule lengths of space and time and outsized quantities of energy figure centre-stage? No clear answer is forthcoming, as no tangible phenomenon needs or finds explanation by means of it. Nothing in the realm of human experience is so small, so active, or so energetic, nor derives explanation on the basis of such quantities.

In an attempt to hold on to psychologically compelling theoretical pictures about nothing found in the realm of human experience, yet sensibly wishing to retain this new form of research within the boundaries of natural science, hope has inevitably come to be placed on the invention of new technology. (In this, his long-drawn-out love affair with such an intoxicating mistress, what will man not hope to mend with more technology!) But because dreams of the likes of accelerators embracing the girth of the galaxy with which to probe the Planck scale directly are nothing short of embarrassing — witness the limits of technological forbearance — the search for indirect emergent phenomena, to which a more realistic technology of the near future might be sensitive, was a cry dying to be uttered, a development waiting in the wings of inevitability. These effects are understood to have their root cause at the Planck scale, but to be amplified or magnified in certain situations, like a cell is amplified by a microscope or molecular activity by Brownian motion. Amelino-Camelia (2008) has reviewed the state and prospects of this tentative enterprise, giving to all outward appearances a measured, yet at bottom truly optimistic view of a quantum-gravity phenomenology soon to be. The physicist's wish is nature's command.

"I know that most men think differently from myself; but those whose lives are by profession devoted to the study of these or kindred subjects content me as little as any. . . . They may be men of a certain experience and discrimination, and have no doubt invented ingenious and even useful systems, for which we sincerely thank them; but all their wit and usefulness lie within certain not very wide limits." (Thoreau, 1849, p. 102)

The quantum-gravity venture, however, is ultimately immune to what these experiments may or may not reveal. Because the theoretical pictures it is wont to make are so abstract, complex, and detached by their very construction methods, namely, pure thought, from anything tangible and real, their forecasts so indistinct and hazy, that it is not these theories that such experiments would test but rather some vague related ideas about what might or might not possibly happen in some limit if spacetime was "foamy" or filled with "tiny gaps." Whatever the tentative results, "foams" and "gaps" can be interpreted variously, so a few knobs could always be readjusted back at the quantum-gravity assembly line for production to continue unhindered — no need to pull the plug.

The situation is this: we have all these theories based on the Planck scale, but they do not explain or help us to understand anything within the realm of our experience. What shall we do? We must slip a referent under these theories, twisted and ambiguous as the task may be. The roots of this attitude can once again be traced to the psyche of the human researcher, who reasons as follows: after so much invested effort, it is inconceivable that it may have been misspent, and I presently racing to nowhere; Planck-scale phenomena must certainly be there, and how could nature be so malicious as to deny us all access to them? Or more assertively: if the mathematics we've come up with does not conform to the natural world, then the natural world had better conform to the mathematics we've come up with! So runs the private pantheistic appeal to the deaf cosmos.

The situation in our hands is fraught with tragic irony. Adrift after a shipwreck, we grabbed onto a log to be saved, but the log we grabbed now drags us away from the shore and in the perilous direction of the open ocean. It is now too late to change our log for another, for all other logs have by now floated away and out of sight. So we must do with our first choice. As we drift unawares into the boundless ocean, people wave at us placidly from ashore; complacently, we wave back. We are now lost again but much worse off: we now believe to be saved and have as a result stopped exercising our ingenuity to actually reach the shore. Once in a while, a swollen chunk of wood will break off our precarious lifeboat, and we will sink another inch into the deep blue sea — but no matter. In moments like these, boastful faith in the overall sturdiness of our log is all we need to keep our spirits afloat.

In question here is a physics gone wrong, because in it the theoretical realm drives the observational realm *completely* and *from the start*. Amelino-Camelia (2008, p. 17) tellingly speaks of " 'theoretical evidence' " in scare quotes, revealing precisely the necessity of this upside-down frame of mind and the psychological discomfort it instinctively produces. Evidence is an outward sign, an indication, something that attests to a truth. It cannot by its very nature be theoretical: what pictures; it is empirical: what is pictured. Quantum gravity's appeal to be guided by the facts comes fatally too late, because, by the time the appeal is made, the field has already managed to acquire a vastness of theoretical prejudices and vest them with interests. Manœuverability is then only allowed for *ad hoc* adjustments, but not, more crucially, for the field's rigid overall identity, for too long matured and moulded in a cast in isolation from the facts.

"I know of those whose serene and wise speculations on this theme would soon reveal the limits of his mind's range and hospitality. . . . Notwithstanding his special acuteness and ability, he is unable to take a fact . . . and behold it as it lies absolutely to be disposed of by the intellect . . . but ventures, or is driven, to make some such desperate answer as the following. . . ." (Thoreau, 1849, p. 102)

Many truths have so far been uncovered in this Martian view of Earthy things, but we have not yet got to the beating heart of the matter, and not until we have done so shall we truly understand the Planck scale in its deepest and darkest recesses. Now then, let us face our self-imposed task fairly and squarely: if the Planck scale did not come from nature, where did it then come from? How come that, in the lack of any evidence, new phenomena are expected to emerge at this scale of things with such forceful certainty — so forceful, in fact, as to guide virtually every thought in quantum gravity? Why these magnitudes? *How come these numbers?* Our Martian minds can only be put at ease after having disemboweled this nagging conundrum. To do so, let us dig into the matter in the light of psychological enquiry one more time.

The quantum-gravity physicist starts by observing that there exists

THEORETICAL CLASH (Q.-G. PROBLEM)

$\downarrow$

GLUE QUANTUM & RELATIVITY THEORIES

$\downarrow$

DIMENSIONAL ANALYSIS

$\downarrow$

PLANCK SCALE

$\downarrow$

"FACTUAL" SITUATIONS

Figure 1: Actual chain of reasoning by the quantum-gravity physicist leading from a purported theoretical clash between quantum and relativity theories, seen as the quantum-gravity problem, through the rise of the Planck scale, and ending with hypothetical "factual" situations (the "big bang," the "very early universe," "mini black holes," forbiddingly energetic collisions) about which theories of quantum gravity are supposed to have something to say.

what he calls a "theoretical clash" between quantum and relativity theories, because each is as elemental as the other, yet uses — so the cliché goes — different, mutually irreconcilable concepts. He calls this a problem, thus setting the stage for the quantum-gravity venture. Since there is now something *called* a problem (observe!), he sets out to solve it. What shall he do? Since no actual phenomena are involved in the shaping of this "theoretical clash," he decides, as it were, to fuse the theories theoretically. Quantum mechanics and general relativity are then to be glued at any cost, the most facile, simplistic way being to dimensionally combine their basic constants G, h, and c. Given the relative mathematical complexity and abstraction involved in the procedure, this action gives him the feeling of having actually done something respectable towards a solution; while having simply postulated, perchance more reasonably, the Planck length to be the radius of the electron would have given the deed a dubious air of indecency, given that, in a Byzantine age, pulling a number out of a hat, merely, lacks the magical reassurance that the application, right or wrong, of an involved procedure automatically affords. Hence the Planck scale, and dimensional analysis as a hasty, but to all appearances decent, means to an end. (More intricate methods, and proportionally all the more estimable for that, to achieve the same preordained goal involve, for instance, the quantization of general relativity.) Uneasy, however, that all of this is not yet about anything, the researcher goes on to dream up situations for his Planck-scale lucubrations to be about: the "big bang" and "early universe" before 10^{-43} s, black holes smaller than 10^{-35} m, particle collisions above 10^{9} J, etc. In a crucial pair of steps, he now gratuitously decrees as obvious that there is need to understand *that*, and that this understanding must lie beyond the limits of present theories. And so he states without further ado something like "distances so small and gravitational fields so strong must be here acting together so that to explain what happens quantum and relativity theories must be considered at the same time." (See Figure 1.) To finish, he conveniently inverts the chain of

Planck black holes are proposed as the paradigmatic denizens of the quantum-gravitational realm but, at the same time, general relativity is said to "break down" at the Planck scale. How can there be black holes where general relativity does not hold?

“factual” situations (q.-g. problem)

$\downarrow$

planck scale

$\downarrow$

quantum & relativity theories together

$\downarrow$

quantum-gravity theories

Figure 2: Inverted and false chain of reasoning, where the hypothetical situations originally dreamt up theoretically (the “big bang,” the “very early universe,” “mini black holes,” forbiddingly energetic collisions) are now presented as facts — are they? — whose proper explanation evidently calls for the consideration of the Planck scale, and therefore for the simple gluing together of quantum and relativity theories. The conclusion is drawn that this must then be the natural basis of each and every quantum-gravity theory. The inversion is performed by a sleight of hand, forgetting that these “factual” situations were originally conjured up on the basis of the Planck scale, and not the other way around.

reasoning and now claims that the said situations are the *facts* the Planck scale is about, the *facts* on which Planck-scale theories are based, the *facts* that *give rise* to the “quantum-gravity problem.” (See Figure 2.)

Cf. the rise of the quantum-gravity problem according to Amelino-Camelia (2008, pp. 1–2).

What shall we make of this? An imagined theoretical clash is no foundation for a genuine physical problem. Two theories cannot clash with each other; each can, on its own terms, only clash with the world, with the evidence that it purports to explain; in that case, a theory is false. Quantum and relativity theories are two true theories of two different sections of reality, in the same way that “blue” is a truthful description of the sky, and “yellow” of honey. But shall we say that “blue” and “yellow” clash because the sky is not yellow and honey is not blue? Two theories cannot be said to clash even if each explained, to our intents and purposes, successfully the same section of reality in different terms; these would clash as much as “blue” and “celeste” do in a characterization of the sky.

No; the only reason one can have for considering quantum and relativity theories together is for a tangible phenomenon to exist *here and now* that sensibly derives explanation from at least the consideration of both. That is, the reason must be the suspicion that each separate theory has something partial and incomplete to say about a certain *observed and problematical* indivisible phenomenon. By way of example of what is meant by this, consider the continually observed phenomenon of change, i.e. time. As studied elsewhere, this derives partial explanation, on the one hand, from general relativity as a clock-reading separation ds or Δs (the physical core of the theory), and on the other, from quantum mechanics as a particular premeasurement or preparation $\sum_i \mathscr{P}(b_i|a_i)$ of material systems: the quantum transition of all systems with property a into systems with property b. Note, first, that events, clocks, and devices preparing material systems into states are the direct referents of the theoretical pictures, all of them tangible things we can see, handle, and affect; and second, that here quantum and relativity theories are

(Meschini, 2008, ch. 10, 12)

PREVIOUS PHYSICAL EXPERIENCE

↓

IDENTIFICATION OF PHYSICAL SYSTEM

↓

DETERMINATION OF ITS KIND

↓

[ENTER QUANTUM GRAVITY]

SELECTION OF CONSTANTS AND VARIABLES

↓

DIMENSIONAL-ANALYTIC PREDICTIONS

Figure 3: Steps in the correct application of dimensional analysis. This is the only way to assure ourselves that the predictions obtained by means of this method will likely possess physical relevance. Dimensional analysis in quantum gravity becomes haphazard by omitting the first three unomittable steps of the procedure.

in relation to time akin to blue and yellow in relation to the phenomenon of the rainbow: both offer partial views on the phenomenon, could give an understanding of green if *thoughtfully* considered together, and yet the full, indivisible phenomenon likely possesses aspects that escape both of these theories: beyond its blues and yellows and greens, we must ultimately strive for the reds, oranges, indigos, and violets of physics as well.

Paying no heed to this key question of phenomenology, resort is conveniently made to dimensional analysis, as it seemingly allows to deal with problems simply and in the abstract. But, as elaborated elsewhere, dimensional analysis is not such a magical tool as to produce relevant results out of thin air. The results it produces will only possess physical relevance when its application has been preceded by extended *experience* with the physical situation and careful thought determining what kind of tangible system it is that we have in our hands. Because there is no actual system under study, quantum gravity skips essential steps in the application of dimensional analysis, as shown in Figure 3, incurring in the illicit application of the method and, naturally enough, in error. As for the "factual" situations postulated, they bear no substance, for consider: (i) *Are* they phenomena? Facts? (ii) How do we know — other than as a result of sheer repetition — that these are anything but *imaginary settings,* that there is anything to understand about them, that it is here and not elsewhere, or nowhere, that quantum and relativity theories must be relevant together? We are insistently told it is *because* they all involve the Planck scale. But did not the Planck scale come from *assuming* that quantum and relativity theories needed to be fused in the first place? The conceptual shambles Planck-scale physics finds itself in is now as evident as it is great.

(Meschini, 2007)

A reading of Bridgman's (1931) brilliant little book on dimensional analysis is all that is required for the physicist to dispel all misguided thoughts on the subject.

Are the very early universe, Planck black holes, and Planck collisions the Aleph, Books of Sand, and Libraries of Babel of a Borgesian quantum gravity?

There is, then, no quantum-gravity problem, because actual problems can only come from the world, not from the prejudices in our heads. To call something a problem is, as Jorge Luis Borges said, an "insidious petition of principle":

> The word *problem* can be an insidious petition of principle. To talk about the *Jewish problem* is to postulate that Jews are a problem. . . . Another demerit of false problems is to promote solutions that are false as well. Plinio (*Natural history*, book VIII) is not content with observing that dragons attack elephants in the summer: he ventures the hypothesis that they do so to drink all their blood which, as everyone knows, is very cold.[b] (Borges, 1941, p. 47)

To develop fantastic theories irrespective of the world around, only to wake up later, too late, to the question of their meaning, is to make *thought about nought*.

In the meantime, by placing the burden of proof upon tentative and hesitant observations to be, ample margins remain for quantum-gravity theories to adjust themselves and shift position if ever confronted by any such distantly binding fact. In other words, by setting its default status as "innocent until proved guilty," quantum gravity retains via the Planck scale the licence to remain in scientific limbo for as long as suitable technology is not available to either corroborate it or decidedly prove it wrong — and when it comes to the latter, nothing short of a Planck microscope, showing that spacetime is *not* foaming fiercely, will suffice. But physics is not a court of law, where the innocence *of a person* always ought to be presumed to prevent mistakenly ruining his life. In question here are ideas, not people. Physics' default status must then be set — as Hardin (1993, pp. 40–43) was fond of saying of ecology's — to "guilty until proved innocent," since it cannot afford to take every claim seriously when in question are matters beyond the realm of human experience and reasonable forbearance, that is, *beyond the boundaries of the physical tradition.*

As is more likely, beyond technology and logical arguments, quantum gravity and the Planck scale will, in practice, stay alive in the memepool only until enough many run out of patience, get bored, decide the jury's been out too long, and move on to more substantial matters, or, in their absence, to the next imposture. Coming to our senses will surely be a long-drawn-out process, but at length it will be perceived that significant physical research, mind-wrenching as it might be, is to be done here and now, not in the daydreams of a far-fetched tomorrow.

"It is so hard to forget what it is worse than useless to remember!" (Thoreau, 1863, p. 368)

Could one describe the moon with the concepts of a cube and a lightyear unit? Naturally not, simply because the moon — that moon we see hanging in the sky — is spherical and about 3500 km in diameter. We must, then, quite simply reject these inappropriate concepts of cube and lightyear, for they do not suit the moon. Now, what kind of scale would be unsuitable for quantum gravity and in need to be rejected? We draw a blank at the unexpected question. Let us rephrase. If, for instance, the Planck length had turned out to be of the order of 10^{-100} m, would quantum gravity *then* have rejected the Planck length and the rest of the scale with it? (And if it had turned out to be of the order of 10^{-350} m? What are the limits of rational forbearance?) It is highly to be doubted. Since, under phenomenologically barren circumstances ("there is no moon"), only internal and therefore insufficient matters of self-consistency, symmetry, simplicity, beauty, and good taste can serve as a guiding light, the sizes of the basic units obtained make no real difference, any size being as good as any. In this way, the actual sizes of the Planck units become, in practice, inconsequential to the validity of the theoretical pictures built upon them. In practice, 10^{-35} m is just as detached from all meaning, so distantly and dismally small, and just as much a disembodied number to juggle with inside the hermetic dream of our quantitative technicalities, as 10^{-100} m. After all, we can always trust observations will adapt themselves to the magnitude of our theoretical prejudice. Once again: the physicist's wish is nature's command.

We come thus to Planck-scale theoretical pictures in which only the relevant disembodied numbers and the quantitative technicalities built thereupon play a role, but in which any underlying conceptual analysis against the background of human experience is largely missing. Such behaviour as is involved in the uncritical acceptance of the Planck scale *whatever the quantities involved* bespeaks then not wisdom or knowledge of the secrets of the universe, but confusion and denial coupled with the desire — or *need,* as we see below — to make learned statements that, in their superficiality and lightness, will effortlessly keep their heads above the waters of prejudice of the current climate of opinion. Nothing more facile, simplistic, and conveniently popular than three plain figures: the darkest enigmas of the cosmos lying naked, for all to behold, on the palm of our hand.

Finally, we ask: what, then, *are* the numbers? Quite simply: those resulting from human observation of and experimentation with the relevant physical things — if and when such things lend themselves to meaningful quantification. So long as such things remain unidentified, no natural referent exists for a theory of quantum gravity. And a theory without a referent, a theory that is not *about*, may be of mathematical or perchance philosophical worth, but it does not and cannot belong in the ranks of physical theories. Genuine physical theories have always been and will continue to be created by men to explain observed natural phenomena, not merely to fill journal pages and engross statistics and curricula vitæ, nor even for the nobler goals of self-referential consistency and mere psychological satisfaction. *To be about or not to be* — this is the unbreakable dictum of the physical tradition.

"Even the facts of science may dust the mind by their dryness, unless they are in a sense effaced each morning, or rather rendered fertile by the dews of fresh and living truth." (Thoreau, 1863, p. 369)

5 And then, what?

Can we hope for down-to-earth enlightenment about the workings of the tangible world out of the lucubrations of the quantum-gravity scholar? Hardly, because his investigations are not about phenomena but divorced from them. Juggling with the borrowed symbols of previously successful physical paradigms cannot create a better understanding of nature when the symbols manipulated, used out of their original context, are not now about nature. Where are the things talked about? What do names and symbols refer to? How do their effects translate into the realm of human experience?

Physically disembodied research paper piles up upon physically disembodied research paper at an ever mounting pace. These are scientific papers about nothing but themselves — truly, an oxymoron. Picture this trend continued indefinitely into the future. Where does it lead? Where are we going? *And then, what?*

By *such* a pile may we hope to scale heaven at last? Cf. (Thoreau, 1854, p. 182)

As Hardin (1960, pp. 344–345) observed, after governments began to take an interest in reaping the fruits of science, science administrators became too fond of auditing scientists' activities, which inescapably led the latter to turn other-directed, i.e. to pay more attention to each other than to the problem at hand. Thus, unveiling the enigmas of the world is not any longer the scientist's main concern; perhaps, not any longer his concern at all. His concern is with fitting in his asphyxiating, overburdening cultural setting, with playing by the hieratic rules of this new world that gets braver by the minute, that has such people in't. The rules, which not long ago consisted simply in the infamous dictum, "Publish or perish," are today much more numerous, much more varied, much more tortuous and twisted. Indeed, the progressive byzantinization of culture has left the relative simplicity of "publish or perish" behind. Today, the scientist's survival requires that he collect "merits" by the pound: posts, expert positions, and positions of trust and administration (what's the difference?) held; citations received; dissertations supervised; articles refereed; visits made abroad (and domestic?), acknowledgements, grants, and awards received; conferences attended; posters presented; talks given; etc. — of these, publications are only one. A new, more fitting dictum seems then to be in order: *Ferret for merit* — and yet, *Haste makes waste*. Now, is it to *be* and *do* something that is meritorious, or to be a *good* something and do something *well?* What is the merit of being a vain referee, a lousy teacher, an absent supervisor, a jejune prolific author, a highly cited charlatan, or of going to Scotland on a science trip that, perhaps, amounted to no more than a visit to Maxwell's grave?

But to focus now on the main issue, let us carry on by concentrating only on the anachronistic dictum: the scientist must publish or the scientist must perish. So publish the scientist will. Pressed to make headway, appropriately understood, as fast as possible, the scientist will naturally follow lines of least intellectual resistance. A meaningful idea that would require ten years, not to say twenty, thirty, or a lifetime, to mature in the mind of one individual is today an impossible brainchild. All the new scientist can afford to do is acquiesce to the coming age of epigonism: to twist and violently reconnect preconceived, previously successful ideas — conceived, in fact, by those who *did* spend a lifetime to think them; — to chew, ruminantlike, the regurgitated products of these finer, keener intellects, in the vain hope that fast-gluing the pieces of our current knowledge together will perhaps uncover some

"Why should we be in such desperate haste to succeed, and in such desperate enterprises?" (Thoreau, 1854, p. 345) new, relevant connection. From the physics camp, the lament is too often heard that the pieces do not fit: quantum mechanics and general relativity, seemingly the pieces of a faulty jigsaw puzzle. Alas! if only blind, deaf, and dumb nature would care about the new physicist's predicament.

"On my return home, it occurred to me, in 1837, that something might perhaps be made out on this question by patiently accumulating and reflecting on all sorts of facts. . . . After five years' work I allowed myself to speculate on the subject, and drew up some short notes. . . ." (Darwin, 1859, p. 3)

The alternative to not grasping and making something of whatever is close at hand would be to refrain from making learned statements and admit to there being nothing much worth saying along these inertial lines of least intellectual effort. In this situation, one had better turn to thinking rather than writing, the former being an essential prerequisite for the latter, but then again this goes against the said yardstick by which the new scientist has his achievements, by nature non-quantitative, measured. The new scientist cannot afford to wait — thinking hard and privately trying out ideas in the meantime — and write only when he has significant ideas to report, for then there would be no bulks for him to present for assessment, and this would compromise his position. Looked at from the opposite end — the perspective of the science administrator — these requirements make perfect sense: if scientists were encouraged to write only when they had significant ideas to report, there would then be no bulks to assay, no weights to weigh, no quantities to count, no citation indices to calculate. And, in line with the reigning Dogma of Existence by the Pound — "If it cannot be counted, it doesn't exist" — how would we then assay scientific merit? By the horribly painful and time-consuming activities of reading and thinking? To the science administrator, Gauß's *pauca sed matura* is anathema.

success: *other-directed* attainment of wealth, favour, or eminence; cf. **achievement:** *inner-directed* accomplishment by means of exertion, skill, and perseverance.

The calamity of this state of affairs is well encapsulated in Upton Sinclair's remark that "It is difficult to get a man to understand something when his salary depends upon his not understanding it!" What is calamitous is not the truth of this statement as predicated of anyone in general, say, the machine operator, for in the sacred name of efficiency, one is sometimes not meant to understand; it is the fact that its truth can now be predicated of one type of man to whom it should apply the least; in fact, to whom it should not apply at all: one of the *quintessential truth-seekers*, the scientist. As a result of the vicious requirements placed upon its artificers, academic science has been savagely turned into an intellectual activity that can only be *successfully* carried out by mass-men, because

"It is for want of a man that there are so many men." (Thoreau, 1863, p. 367)

> Intellectually, a man is of the mass who, confronted by a problem, contents himself with thinking what he already finds in his head. On the other hand, distinguished is the man who rejects what he finds in his mind without previous effort, and who only accepts as worthy of him what is still above him, requiring a new leap in order to be reached.[c] (Ortega y Gasset, 1929, p. 128)

"In the long run men hit only what they aim at. Therefore, though they should fail immediately, they had better aim at something high." (Thoreau, 1854, p. 125)

The dilemma of this situation and the solution to it, left indeterminate due to its current inviability, have been pointed out by Joseph J. Thomson:

> If you pay a man a salary for doing research, he and you will want to have something to point to at the end of the year to show

> that the money has not been wasted. In promising work of the highest class, however, results do not come in this regular fashion, in fact years may pass without any tangible result being obtained, and the position of the paid worker would be very embarrassing and he would naturally take to work on a lower, or at any rate a different plane where he could be sure of getting year by year tangible results which would justify his salary. The position is this: You want this kind of research, but, if you pay a man to do it, it will drive him to research of a different kind. The only thing to do is to pay him for doing something else and give him enough leisure to do research for the love of it.

Quoted from (Hardin, 1960, p. 344).

Perhaps, scientific merit is after all best left for posterity and nature to assay, or, less democratically and more appropriately, for those few who understand today what scientific merit *is*; the science administrator, as Thomson points out, should rather assess the merits of the scientist by some other standard, e.g. by the quality — repeat: *quality,* that radically uncountable but not at all abstract noun — of his teaching; or by his skill to inspire and lead the best scientifically inclined members of the new generation into the archdifficult activity of critical, independent thinking-about-something that stands a chance to make a difference; or by the clarity of his expression, the depth of his thought, his magnanimity, his wisdom. But I let myself get carried away: the assessment of any such high virtues is certainly beyond the reach of the lowly administrator, himself the product of mass-culture, a mass-man amidst the masses. Sir Thomson seems to have had a point in leaving indeterminate the "something else" the scientist should be paid for doing, as the only type of activity the administrator is capable of assaying is the meaningless throwing of stones over a wall, and then back again, "merely that they might earn their wages." Stones can be mechanically counted, or better yet, weighed by the pound at one fell swoop. Quality, magnanimity, wisdom can only be perceived by those who in some measure practice or possess them. Thus, distinction, egregiousness, quality in any form being bureaucratically inestimable, whatever Thomson's "something else" may be, it will not do as a standard for the selection of *great* men who will, in the ample leisure given them, then proceed to do research *of the highest class* for the love of it; whatever Thomson's "something else," it must necessarily be, today, something assayable bureaucratically, in bulk, and only those who excel at stone-throwing would become selected by its means — and what kind of research are we to expect from stone-throwers who, in their leisure, get down to research for their love of it?

"I would not be one of those who will foolishly drive a nail into mere lath and plastering; such a deed would keep me awake nights. . . . Drive a nail home and clinch it so faithfully that you can wake up in the night and think of your work with satisfaction. . . . Every nail driven should be as another rivet in the machine of the universe, you carrying on the work." (Thoreau, 1854, p. 348)

To pose the ecolate question once again: *And then, what?* We have found the question has two different, complementary answers. From a purely physical point of view, the answer is simply, "And then, nothing." Nothing insofar as nothing of real value is thus achieved and contributed to science; nothing is gained, nothing is lost: as in Byzantium, development has been arrested. This is diametrically opposed to the situation in ecology — the situation for which Hardin conceived the ecolate question — where the answer is all too often, "And then, disaster." Disaster in a very real sense, as short-sighted progress and economy-driven growth can, in the long run, only do harm to the inhabitants of a finite world. But in physics, too, the answer can be far from the above innocuous "nothing" and likewise "disaster." This is so when we look at physics as a sociological activity. In that case, the answer to the ecolate question is, "And then, fraud or fiasco." Which of the two it is to be depends on the physicist's awareness and true intentions.

If, oblivious to the shackles of his research setting, he piles paper upon disembodied paper in the honest belief that he is contributing relevantly to physics, in question is the lesser evil of fiasco; in other words, total failure. As the years and decades pass, he may naively begin to wonder, impelled by a second reigning dogma, the Dogma of Quality by the Pound — "If it's heavier, it's better" — why so many tons of paper have led to no real progress, the same old questions continuing to haunt research. "Have we, after all, learnt nothing significant all this time?" he enquires with honest puzzlement as he nears the end of his life. Thus, the total failure of physics to achieve the very goals that stand as its reason of being ensues from this baroquish fixation in which the act of producing is more important than the result achieved. If, on the other hand, aware of being embarked on a race to nowhere, the physicist is happy to sail on so long as his comfortable cabin in the ship of science is secured, in question is fraud. A deliberate deception in which any experienced uncertainties are covered up and brushed aside, and in which one's own work must be praised at every opportunity as a remarkable success. In this setting, a scientific paper is nothing more nor less than a means to advertise ideas as though consumer goods and to manipulate readers and policymakers into believing in their worth. Because success is today, in academia as elsewhere, a thing manufactured from within by a frivolous and irresponsible hijacking appeal from the mass-man to the masses, fraud ensues, as honesty is a luxury one cannot afford.

"Up come the books, but down goes the wit that writes them." (Thoreau, 1854, p. 191)

Governments only tried to reap the fruits of science, and the appointed bureaucrats to simplify their job — but in science as in ecology, as the sage had it, *we can never do merely one thing*.

"I hardly know an *intellectual* man, even, who is so broad and truly liberal that you can think aloud in his society. Most with whom you endeavor to talk soon come to a stand against some institution in which they appear to hold stock, that is, some particular, not universal, way of viewing things." (Thoreau, 1863, p. 364–365)

6 Physics meets psychology at the Planck scale

The simplest questions are the hardest to ask. Who will ask them? The tunnel-vision expert seems our last hope, as his thoughts are trammelled by the weight of his disembodied quantitative technicalities, his vision nearsightedly focused on the mathematical details of his investigations.

We turn then to the mythical man from Mars. His feet firmly on Martian ground, his vision wide-ranging, and his judgement unclouded by excessive reading of optimistic research papers, he calmly voices his literate, numerate, and ecolate thoughts unintimidated by the proficiency of the Earthy expert:

> Why a mechanical theory of quantum gravity? What is the thing that moves? Has any of you seen it? If it moves in space and time, how does your quantum gravity intend to give a new, groundbreaking explanation of these very concepts, as I've heard it means to?
>
> Why is the mechanical object so small, so restless, so energetic? Does smaller mean more elemental? Why, as uniquely creative as each of you is, do you all make theoretical pictures in which the Planck scale is paramount, if no natural phenomenon on Earth or Mars requires explanation at this scale of things?
>
> As I've gathered, the goal of your scientific theories is to explain the natural world. Do you, here and now, make them to achieve by their means the explanation of some phenomenon — or to achieve something else?

"I occasionally observed that he was thinking for himself and expressing his own opinion, a phenomenon so rare that I would any day walk ten miles to observe it. . . ." (Thoreau, 1854, p. 216)

No answers are forthcoming. The tunnel-vision expert learns to his chagrin that the simplest questions — the ones he leaves unasked — are the hardest to answer, too.

What would a man who broke new ground in physics from the bottom up, on the basis of natural phenomena, of observations and experiments, have had to say about the Planck scale as a foundation for better physics? Would a man of the physical tradition, the tradition now swiftly vanishing from the realm of frontier physics, if set to ponder the way forwards, have come to the Planck scale, too? The answer to the former question is "nothing;" the answer to the latter, "not at all."

Pondering the divergences of quantum field theory, in *Physics and philosophy* Werner Heisenberg makes general considerations along the lines of dimensional analysis. Availed with Planck's constant h and the velocity of light c, he speculates on the need for a third fundamental constant, such that a complete, physically meaningful length-time-mass set could be obtained. As this analysis is carried out, the twenty-first-century reader becomes possessed with a mounting feeling that Heisenberg is on the brink of introducing the gravitational constant G and deriving the Planck scale from the set $\{h, c, G\}$. But these expectations are disappointed, as Heisenberg, basing himself on available experimental evidence, writes:

> *Judging from our present knowledge* of these [elementary] particles, the most appropriate way of introducing the third universal constant would be by the assumption of a universal length the value of which should be roughly 10^{-13} cm, that is, somewhat smaller than the radii of the light atomic nuclei. (Heisenberg, 1958, p. 111, italics added)

Why 10^{-15} m and not 10^{-35} m? Should Heisenberg catch up with the times? Or should the new physicist catch up with the observational evidence?

And what about the very man who thought up the units in question, Max Planck himself? What would he have had to say? Such an exemplary member of the physical tradition as he was, it may be here ventured that if Planck had known that, as a result of some innocent play fiddling with the constants of nature once back in 1899, his name would end up heading, a century later, the ranks of today's debacle in frontier physics, he would probably think twice before allowing his pen to scribble what would prove such a mentally infectious *capriccio*.

In view of its shaky literate, numerate, and ecolate foundations, why is yet so much thrust put into the essentialness of the Planck scale? A deeper answer emerged here by taking into account the psychological make-up of the human researcher. The human mind, as it seeks to reach out beyond the limits of knowledge, craves nonetheless the familiarity of mechanical concepts and well-established intuitions, the ease of geometric tools, the comfort and safety of geometric containment, and the fast lane of intellectual inertia, of formulaic, epigonic repetition.

"I had not lived there a week before my feet wore a path from my door to the pond-side; and though it is five or six years since I trod it, it is still quite distinct. . . . The surface of the earth is soft and impressible by the feet of men; and so with the paths which the mind travels. How worn and dusty, then, must be the highways of the world, how deep the ruts of tradition and conformity!" (Thoreau, 1854, p. 343)

As to men's geometric needs, Stanisław Lem has bitterly lamented that the human imagination must visualize everything. Confronted by a truly alien landscape, his character laughs

> at the mighty efforts made by the artists of Earth to reach beyond the boundary of human imagination (which must visualize everything); at how the poor devils beat against the walls in their minds; and at how little, really, they departed from platitude, though straining to the utmost to depart — while here, in a single acre, there was more proud originality than in a hundred of their anxious, anguished art shows. (Lem, 1986, p. 31)

The processes of creation at work in science and art are all too similar, and these two spheres of human enterprise have been rightly likened by many a thinker. It is then little wonder that the creative pitfalls that befall many an artificer of art should also befall many an artificer of science.

As to men's intellectual inertia, said the Spanish philosopher with characteristic acuity,

> We are normally under the impression that we live amongst sleepwalkers who march forwards in life submerged in a hermetic dream . . . in which their ideas are not an alert and conscious reaction in the face of things, but the blind and automatic use of a repertoire of formulas that the environment insufflates in the individual. . . . It is undeniable that a large part of science and literature has also been done in somnambular trance. . . .[d] (Ortega y Gasset, 1927, p. 143)

So long as it pays more to do science in our night's sleep than in the morning hours of our most refined and intense conscious perception, the present slumber of physics shall not know the break of dawn.

In the particular instance examined in this enquiry, this state of affairs led the human mind to trapping itself in the marginality of a 10^{-103}-cubic-metre cage — an intellectual sanctuary, as it were — from which it is unwilling to peek out, much less escape. In this light, the Planck scale stands today as the *leitmotiv* of human beings' psychological and sociological needs as they attempt new physics. It is the scale that came most handy to do a job already in dire need of being filled: if the gravitational constant G, Planck's constant h, and the speed of light c had not combined to produce it, another scale would have been ordained to take the vacant role.

We now see that, if physics meets anything substantial at all at the Planck scale, then it is not, as the title of a perplexing book gloriously announces at the strident sound of trumpets and cymbals, something so grand as philosophy, but rather — unexpected to the hard-boiled physicist imbued with the ideal of human-free objectivity — less grand but more pertinent psychology: the psychology of the human researcher who, adrift in the phenomenon-barren sea of quantum gravity, instinctively reached out for the promise of rescue embodied in a flimsy passing log.

Martian envoy

One hundred and fifty Earth-years ago, Henry Thoreau, then Martian envoy to Earth in exploration in the neighbourhood of Walden Pond (42.4384° N, 71.3420° W), spoke thus of what he saw. Men, he wrote,

> are in great haste to construct a magnetic telegraph from Maine to Texas; but Maine and Texas, it may be, have nothing important to communicate. Either is in such a predicament as the man who was earnest to be introduced to a distinguished deaf woman, but when he was presented, and one end of her ear trumpet was put into his hand, had nothing to say. As if the main object were to talk fast and not to talk sensibly. They are eager to tunnel under the Atlantic and bring the old world some weeks nearer to the new; but perchance the first news that will leak through into the broad, flapping American ear will be that the Princess Adelaide has the whooping cough. (Thoreau, 1854, p. 144)

"Seen from a lower point of view ... [these] are, in many respects, very admirable and rare things, to be thankful for, such as a great many have described them; but seen from a point of view a little higher, they are what I have described them; seen from a higher still, and the highest, who shall say what they are, or that they are worth looking at or thinking of at all?" (Thoreau, 1849, p. 101)

Judging from the state of things on Earth as I have now found and described them in this enquiry, in the intervening time, much indeed has changed upon this planet, but nothing, after all, has changed about mankind.

Our then Martian envoy to Earth also left behind guidelines to future fellow explorers who, like myself, dared venture towards this troubled spot of the planetary system, as follows:

> Let us settle ourselves, and work and wedge our feet downward through the mud and slush of opinion, and prejudice, and tradition, and delusion, and appearance, that alluvion which covers

> the globe, through Paris and London, through New York and Boston and Concord, through church and state, through poetry and philosophy and religion, till we come to a hard bottom and rocks in place, which we can call *reality*, and say, This is, and no mistake; and then begin, having a *point d'appui*, below freshet and frost and fire, a place where you might found a wall or a state, or set a lamp-post safely, or perhaps a gauge, not a Nilometer, but a Realometer, that future ages might know how deep a freshet of shams and appearances had gathered from time to time. (Thoreau, 1854, pp. 177–178)

Having gone beyond the meaninglessness of human conventions and clichés, beyond the farcicality of insincere human rhetoric, beyond the asphyxiating straitjacket of a hieratized human culture — and having only thus truly comprehended — my Martian mind is now at ease.

Original quotations

a ¿Qué sentido tiene esto? La ciencia ha de resolver hoy sus problemas, no transferirlos a las calendas griegas. Si sus métodos actuales no bastan para dominar hoy los enigmas del universo, lo discreto es sustituirlos por otros más eficaces. Pero la ciencia usada está llena de problemas que se dejan intactos por ser incompatibles con los métodos. ¡Como si fuesen aquéllos los obligados a supeditarse a éstos, y no al revés! (Ortega y Gasset, 1923, p. 162)

b La palabra *problema* puede ser una insidiosa petición de principio. Hablar del *problema judío* es postular que los judíos son un problema. . . . Otro demérito de los falsos problemas es el de promover soluciones que son falsas también. A Plinio (*Historia natural*, libro VIII) no le basta observar que los dragones atacan en verano a los elefantes: aventura la hipótesis de que lo hacen para beberles toda la sangre que, como nadie ignora, es muy fría. (Borges, 1941, p. 47)

c Es, intelectualmente, masa el que ante un problema cualquiera se contenta con pensar lo que buenamente encuentra en su cabeza. Es, en cambio, egregio el que desestima lo que halla sin previo esfuerzo en su mente, y sólo acepta como digno de él lo que aún está por encima de él y se exige un nuevo estirón para alcanzarlo. (Ortega y Gasset, 1929, p. 128)

d De ordinario, se tiene la impresión de vivir entre sonámbulos que avanzan por la vida sumergidos en un sueño hermético . . . en que las ideas no son reacción despierta y consciente antes las cosas, sino uso ciego, automático, de un repertorio de fórmulas que el ambiente insulfa en el individuo. . . . Es innegable que mucha parte de la ciencia y de la literatura se ha hecho también en trance sonambúlico. . . . (Ortega y Gasset, 1927, p. 143)

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"Any man more right than his neighbors constitutes a majority of one already."