A Fundamental Loop

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Abstract In a bootstrapping view of reality physics, mathematics and cognition are deemed to be equally fundamental. Democritus, Pythagoras and Anaxagoras are taken to be originary figures and historical aspects are sketched.

Fish and birds do not know what is fundamental. They are stupid, of course. And they move freely in all three dimensions. Humans however stick to an equipotential plane, or more exactly, being reasonable, they live in a differentiated (2+1)d world. Two of the dimensions are indifferent but the third one is particular. Only what develops along it is fundamental and the rest is, well, superficial. 'Bottom up' or 'top down', both methods move along the right axis. We value higher things and, also, profound things, that is - the fundamental ones.[1]

Being a fundamentalist

Language functions in the present: words are used with their meanings from the latest stage, not the ones dug from the past. The qualification 'fundamental' is an ossified metaphor (or a catachresis), but today obviously it means something else. We might read, for instance, that "Physics is more fundamental than chemistry" or that "Set theory is fundamental for mathematics". Detailing their view, the authors of such assertions usually point that a fundamental domain allows to explain a larger one through a procedure called reduction. The goal of their rhetoric strategy is to convince that "x is nothing but…" or "it is just…". So, chemistry is just the physics of the outer electrons in atomic shells or life is nothing but the chemistry of carbon with some complications.

The reductionist approach has its own problems and critique: cases of genuine reduction are rare. In order to assert credibly that a more fundamental level has been accessed the reduction should be both methodological and ontological[2] (as far as these two realms can be meaningfully discerned). This is a guiding idea, an 'ideal type', which is not expected to be a practical possibility, rather science looks for the main term in a kind perturbative approach: everything is decomposed into a principal component and details. Identifying such major features within knowledge is the purported aim for the development of fundamental theories.

"There is no fundamental theory" flatly asserted David Bohm.[3] and his ideas about science in general and (quantum) physics in particular are seen as an alternative to the mainstream thinking. If 'holism' is the keyword for Bohm, its antonym, 'atomism', is undisputedly a favorite of Richard Feynman. According to him, it is simply the most basic idea reached by humanity[4].

> *If, in some cataclysm, all of scientific knowledge were to be destroyed, and only one sentence passed on to the next generations of creatures, what statement would contain the most information in the fewest words? I believe it is the atomic hypothesis (or the atomic fact, or whatever you wish to call it) that all things are made of atoms —little particles that move around in perpetual motion, attracting each other when they are a little distance apart, but repelling upon being squeezed into one another… Everything is made of atoms. That is the key hypothesis. The most important hypothesis in all of biology, for example, is that everything that animals do, atoms do. In other words, there is nothing that living things do that cannot be understood from the point of view that they are made of atoms acting according to the laws of physics.*

> *What do we mean by "understanding" something? We can imagine that this complicated array of moving things which constitutes "the world" is something like a great chess game being played by the gods, and we are observers of the game. We do not know what the rules of the game are; all we are allowed to do is to watch the playing. Of course, if we watch long enough, we may eventually catch on to a few of the rules. The rules of the game are what we mean by fundamental physics. Even if we knew every rule, however, we might not be able to understand why a particular move is made in the game, merely because it is too complicated and our minds are limited.*

A longish quote but worth its space as it encapsulates the essence of a well established fundamentalistic attitude: there is a truth ("atoms") that explains everything, even if most of it remains beyond our grasp. As an historical aside we could note that the idea of 'physics, first" has had a tortuous history. The editors of Aristotle, working a few centuries after his death, had a rather neat collection of his physical writings and some messed manuscripts about philosophy, so books on physics came first and philosophy came next as 'meta-physics'. Aristotle, just as his predecessors and contemporaries, shared the opinion that it is metaphysics which elucidates the fundamental questions and the details come later. A paper by contemporary metaphysician Alyssa Ney recently asked *Are the Questions of Metaphysics More Fundamental Than Those of Science?*[5] as a reply in an ongoing debate about 'naturalized metaphysics'.

A structure of options

It was Democritus, who offered a coherent expositions of the atomist idea, cherished by Feynman, and in the interval it has also acquired a complicated history. Originally everything boils down to Atoms and Void, A's and not-A's, 1 and 0, and their combinatorics. Articulating clearly and exhaustively an all encompassing idea is rather hard, so it is rather trivial to note that without the magic of 'Infinity' atomism loses much of its attraction. No matter how large is the combinatorial space, Infinity dwarfs it and compels it to repeat itself. Regularity is what science expects and it is only in the 19th.c., when history attempted to acquire some scientific aura, that 'the eternal recurrence' came to the attention of a large public. Its inevitability was demonstrated by Louis-Auguste Blanqui, in a booklet filled with cosmological musings[6] while he was held in prison for his political activities. But at that time many serious scientists, who adhered to positivism (e.g. Wilhelm Ostwald, a nobelist for 1909, or Ernst Mach), thought atomism a purely metaphysical idea, outside the scope of science.

Of course the ancient physically minded atomists had opponents right from the start: the so called Pythagoreans[7] asserted that the Limited and the Unlimited are the basic categories of the Universe. It is a moot point what views these early thinkers actually held, but later they came to be known under a striking slogan: everything is number. So, from the figure of Pythagoras down to contemporary author Max Tegmark, the idea of some kind of a mathematical universe has acquired a respectable pedigree. Accurately described as a mathematical fundamentalist, Tegmark is also presented as 'radical platonist'. An other twist in history should be noted to explain this appellation: Plato was deeply impressed by the mathematicians' achievements and created an accessible imitation in order to promote his political-philosophical agenda; after an eclipse of some two millenia, his works came back in circulation and unheedingly people started talking about 'mathematical platonism', as if mathematics aped platonism and not the obverse. Plato himself could have been a 'radical platonist' if his *Timaeus* had been read in the appropriate way. In this famous work he explained the world as consisting of regular geometric solids, (known today as the 'platonic solids') whose substance remains unspecified. His text could be seen as solving a

construction task, “given the solids, build a world”. Later history however focused on the constructor and ignored the mathematical underpinning of the story.

Democritus and Pythagoras could be taken as the originary figures of physical and mathematical fundamentalism (and/or reductionism). Matter and void or form and formlessness are the pairs of opposites that logically exhaust the universe, but, of course, they do not exhaust the space of possibilities. Anaxagoras explained the world by the interaction of two other entities which came to be assimilated in tradition loosely to ‘mind’ and substantial ‘matter’, embodiments of a pair much like activity and passivity. That these terms are incommensurable with preceding views transpires through the formulation of his main principle “everything in everything”. His substances are without ultimately separable components, a concept known currently as ‘gunk’[8], while the traditional name ‘nous’, mind or intellect, has been kept for the other entity which is both ubiquitous and distinct. Most notably nous does not imitate something external to be called “reason” but intrinsically constitutes it. As any other notable ancient Greek thinker, Anaxagoras was proposing some alternative to mythological and theological accounts of the world. His active or intelligent principle, ‘nous’, was obviously not godlike and totally non-anthropomorphic, so we are not surprised to learn that ultimately Anaxagoras was brought on trial for impiety.
The idea of self-organization has been conceived and when later Plato resorted to a geometrist-demiurge to explain the well ordered world, it was actually a regressive move, which historical circumstances promoted and sustained for along time. More than 2000 years later, in the early 19th c. Hegel was still struggling to imagine an evolving world without offending the theologians, but only with a more limited scope Darwin (almost) succeeded. The physicists of the epoch had generally agreed that any organized form, left without supervision, is bound to deteriorate. The idea of a natural emergence gained ground very slowly and at the end of the 20th c. nobelist Philip Anderson still had to deploy rhetorical skills in order to make it acceptable to the physicists’ community[9]:

> *“One may make a digital computer using electrical relays, vacuum tubes, transistors, or neurons; the latter are capable of behaviors more complex than simple computation but are certainly capable of that; we do not know whether the other examples are capable of "mental" phenomena or not. But the rules governing computation do not vary depending on the physical substrate in which they are expressed; hence, they are logically independent of the physical laws governing that substrate. This principle of emergence is as pervasive a philosophical foundation of the viewpoint of modern science as is reductionism. It underlies, for example, all of biology, as emphasized especially by Ernst Mayr, and much of geology. It represents an open frontier for the physicist, a frontier which has no practical barriers in terms of expense or feasibility, merely intellectual ones. ”*

Few people seem to agree that ancient atoms have been just a metaphysical idea, irrelevant to contemporary science. Certainly more would object that Anaxagoras has proposed a valid idea, even if their arguments might turn to be less than fully rational. Collective phenomena, reflexivity and emergence are still tentatively explored or though about and envisaging the issue of their irreductibility pertains to some *philosophia naturalis* which could be conveniently attached to the name of this less known Greek philosopher. And, by the way, two scholars argued in a book length study that he was entitled to be seen as the first physicist.[10]

Knowledge, that could claim to be fundamental, appears to have three basic forms: reductionst, descriptive, or emergentist. These methodological descriptions imply usually some kind of ontological commitment, e.g. to substance, to form or to process; more conversationally - to matter,

maths, and mind. Pointing to established disciplines would suggest physics, mathematics and philosophy, which introduces further imprecision and confusion, so perhaps we could stick to the symbolic names of Democritus, Pythagoras and Anaxagoras. The candidates for a fundamental status being singled out, the jury is set to decide. Ready to hear the verdict, we should pause for a moment. Is there a reason to think that since in any case we can say that one view is more fundamental than some other, a most fundamental one should exist? Why should we think that such a relation is necessarily transitive?

Roger Penrose discovered the tribar illusion when he was in his twenties and three decades later Douglas Hofstadter made popular different 'strange loops' and 'tangled hierarchies'[11]. Mathematicians have been long aware of non-transitive loops and bootstrap model theories came to be developed in physics. Perhaps it was Efron's dice that demonstrated convincingly the possibility of non-transitive relations. Today this paradoxically looking structure features notably in Roger Penrose's books as a cyclic arrangement of 3 'worlds', consisting of matter, mathematics or mind. The physical world appears to be 'governed' by mathematical 'laws', which are generally discovered by minds, embodied in matter: either with a full overlap or just partially, two successive figures in *The Road to Reality* present the same idea[12]. The unavoidable conclusion is that there is no fundamental level, at least in the commonly understood sense of these two terms.

Discussions

Penrose had already exposed at some length this idea in a book issued from his Tanner lectures of 1995 where it is published with brief critical remarks by some notable thinkers[13]. The short presentation in his later book has served as focus to a discussion held by three physicists in Princeton[14]. Interestingly, these critics tacitly agree that a cyclic or non-transitive model of reality is unsatisfactory but disagree about the reasons and spend much time debating where the cycle should be cut. Their views are labeled 'fundamentalist', 'secular' and 'mystic'; the fundamentalist avocates a single basic area, the secularist proposes more than one and the mystic rejects the 3 proposed, favoring something still unknown[15].

The structural identity with the thesis explored here is evident, even if there is a slightly different distribution of the elements involved. Penrose outlines a rather traditional *platonic* world, which includes more than mathematics, and somehow separates it from the realm of mental-in-general. For the present discussion a *pythagorean* world of mathematism is separated and a fuzzy world of reason(ableness) is outlined. Concurrently we might note that there is some vagueness about the entity we call 'information'. "Storing up disparate information for selective future use" appears to be just one more convoluted definition.

"What is the wisest? 3." This may sound like a koan, but it is among the preserved fragments of Pythagorean lore. A straight logical classification proceeds by binary oppositions, producing number of terms that is a power of 2, while using independent predicates. That is, simply considered, things are either A or not-A and, further, A.B, not-A.B, A.not-B or not-A.not-B. The only way to obtain three cases is to produce some kind of disbalanced tree, recreating the traditional genus-and-species mix: separating A from not-A and only within not-A B and not-B are to be distinguished. Obviously, logic does not offer any straight way to arrive at a genuinely equivalent tripartition. This can only strengthen the reserves against a Penrose-like proposal for 'no-fundamentals'. Questions about features as materiality, temporality, awareness inevitably will produce skewed partitions, which actually repeat the original distribution. For instance, mind and maths are considered to be non-material, maths appears to be intemporal while matter and mind are temporal, and awareness is ascribed only to mind. Such fault lines are usually exploited in arguments which often tend to be not just reductive but eliminative.

Actually 3 is a number most easily arrived to, not by logic, but by analogy: between any two items a third one is posited. The cyclic arrangement allows to escape an otherwise proliferating regress: for any pair there is already a mediation, as by default, if no preferred or 'fundamental' direction is imposed. Tegmark and coauthors spend much time in discussions about cutting different links but somehow fail to comment that in a cyclical structure it forces us to consider the otherwise ignored roundabout way.

Any two allegedly fundamental disciplines could be supposed to derive from the third and a methodological reductionist circle is not invraisemblable, e.g. a good theory of mind explains the syntaxis and semantics and further formal mathematics and physical interpretations. Ontologically it might be surmised that between any pair the third component somehow 'emerges': the 2 cases, "maths out of matter and mind" or "mind out of matter and maths" are rather trivial, the problematic one being some derivation of matter from maths and mind. Noting that Tegmark already has proposed maths as the sole source of everything else, this should not look so extravagant. But mostly, here is a hint that 'nous', 'geist', 'mind' or whatever name is chosen, should be thought about in some different manner, yet to be elucidated. If indeterminism and uncomputability are taken seriously, not just as negative terms denoting temporary trifles, the whole configuration could appear more convincing.

Untimely musings

This topological argument helps to override an other unstated premise of the assumed standard view: the world we deal with develops in time; brute nature precedes life and only latecomers conceive mathematics. Cut and stretched along the time axis the cycle matter, mind, mathematics is seen as a hierarchy. Mathematics however does not deal with time and contemporary physics, which ultimately developed from Greek geometry, has still a rather ambiguous attitude towards it. To put it bluntly, time, as understood by most humans, is said, by many scientists, to be just an illusion. As if by some cosmic irony, just when relativistic physics almost succeeded to banish time, the Big bang scenario turned the whole of physics into (big) history: earlier became more fundamental with a vengeance. But at this stage it became obvious that a world, discussed as we presently do, is not just *any* world and, with reference to some "anthropic principle", philosophical considerations started cropping most insistently in physical theory. The seemingly innocuous traditional formula "given a X, what.." came to be heatedly debated: "what does it mean to be given?"[16], how is it defined in such and such context. A surprising turn had come about when set theorists became aware that without the explicit (and explicitly named) axiom of choice some results are inaccessible; the opposite alternative, later known as an axiom of determinacy, made mathematics appear as somehow impoverished. A reference frame, as a philosopher wittily noted, is nothing but the cartesian subject in disguise. So, when in 1922 Bergson opposed Einstein, the gist of the debate became his thesis that humans built clocks because they knew time and not that they infer the existence of time from functioning clocks[17]. As the question 'what is time' demonstrates, meaning develops in a circular way. Interpreting is not just recognizing (as Platonic anamnesis would have it), it is not a one way trip from Kolmogoroff's axioms to statistical physics and to a cognitive illusion. Time would not emerge from probabilities if it was not already hidden in their conception.

It was only in the 19th.c that philosophy separated from natural science and mathematics started drifting away from physics. A major achievement at that time appeared to be the methodological founding of analysis; mathematics was seen to be possible without the negative concept of infinity. Science in general was conceived as a rational extending of finite knowledge. Asserting that reality is just a particular case to be singled out from some infinity would have been then scientific non-

sense or a regress into theological thinking; appealing to 'randomness' was a well known rhetorical move that transforms the lack of understanding and explanation into something positive. Physics would discover soon further material limitations, e.g. a maximal finite speed for signals and a minimal amount for energy. During the 20th.c., as a most successful ('progressive') science, it started ascribing or denying reality to mathematics concepts at will and carelessly argued about randomness and infinities. Without restraints its pretence turned more and more to be a total fundamental science, inscrutable for non-initiates and immune to criticism from outside.

Outlining their positions in the Penrose debate, Tegmark and his coauthors commented the overtly religious shading of the labels and noted that the 'secularist' has to be seen as a non-believer, which neither the fundamentalist nor the mystic are. And only the 'secular view' holds in the present, while its alternatives are elsewhere. A "temporal naturalism"[18] has been outlined as an alternative by Lee Smolin who also wrote about prophets and mystics, those who expect the future final theory or ascertain its existence outside of time. Physics, mathematics and positive knowledge in general emancipated from religion, for which philosophy had been a 'handmaiden' (ancilla theologiae). On one side remains perhaps a grudge and on the other - the suspicion of domineering wishes. The division of competences which occurred in the modern appears to show that a mono-archic vision is neither feasible nor desirable. Exploring the loop in which mind, matter, and maths are entangled allows to conceive that nothing is fundamental.

[1] For what is either deep or high Latin has a single word, the adjective altus.

[2] For details see *Scientific Reduction* in The Stanford Encyclopedia of Philosophy

[3] Bohm D., *Wholeness & Implicate order* p.191. (For the present purpose we observe that a term usually treated as negligible allows for Bohm's alternative to mainstream quantum mechanics.)

[4] *The Feynman Lectures*, the introductory topics having been published as *Six Easy Pieces: Fundamentals of Physics Explained* (1998). Feynman remarked: "We shall have to limit ourselves to a bare description of our basic view of what is sometimes called fundamental physics, or fundamental ideas which have arisen from the application of the scientific method".

[5] Ney A., *Are the Questions of Metaphysics More Fundamental Than Those of Science?*Draft of Nov. 1, 2017; Jaksland R *The Possibility of Naturalized Metaphysics*

[6] Blanqui L., *L'éternité par les astres* 1872; this counter-intuitive feature is not restricted to 'island universe' models and tends to reappear in contemporary cosmologies, see e.g. Tegmark M., *Parallel Universes* (2003), Sci. Am. **288** (5): 40–51 and later work.

[7] The appelation is commonly understood, even if the historical reality behind it has became deeply problematic (since W. Burkert pionnering work; see L. Zhmud)

[8] For a brief treatment of these non-standard views see Marmodoro A, (2015). *Anaxagoras's Qualitative Gunk*, British Journal for the History of Philosophy, **23**:3, 402-22, with more details in her recent monograph *Eveything in Everything*: *Anaxagoras' Metaphysics* (2017).

[9] Anderson P., 1995, *Physics: the opening to complexity*, Proc. Natl. Acad. Sci. USA v.**92**, p. 6653-4

[10] Gershenson D. Greenberg D, (1964). *Anaxagoras and the birth of physics*, New York: Blaisdell Publishing Co.

[11] Hofstadter D., *Godel Escher Bach* (1979)

[12] Figs. 1.3 and 1.4 in Penrose R., *The Road to Reality* (2004)

[13] Penrose R., *The Big, the Smalland the Brain* (1997), includes comments by A. Shimony, N. Cartwright, and S. Hawking: see Fig 3.3; earlier it appears in his *Shadows of the Mind* (1994)

[14] Hut P., Alford M., Tegmark M., *On Matter, Maths and Mind*, Found. of Phys.**36** : 765-794, 2006 (arxiv 0510188)

[15] Monism, pluralism (dualism), holism are three other possible labels. Tegmark is also a fully fledged reductionist as he endorses a mathematical ontology along with a full theoretical reduction, shown as a directed graph in his paper *The Mathematical Universe*, Found. Phys (2008) **38**: 101–150 (Fig.1, p.103)

[16] That 'the given' (lat. datum, pl. data) is 'theory ladden' seems to be a commonly accepted notion, which usually curtails its philosophical discussion.

[17] For details see Canales J., *The Physicist and the Philosopher: Einstein, Bergson and the Debate,* 2015

[18] Smolin L., (2015). *A naturalist account of the limited, and hence reasonable, effectiveness of mathematics in physics,* arxiv 1506.03733. Smolin also speaks about 'prophets' and 'mystics'.

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