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Walking on the beach of Helgoland with Alexander, Carlo, and Werner: Arguing about Marxism versus Positivism

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CONTEXT: This study discusses a Marxist view of physics—as a research field—that helps to give an operational understanding of nature to facilitate our survival as a species. In particular, in this paper, I deal with quantum mechanics in the version of Carlo Rovelli's relational quantum mechanics (RQM).

In 1925, Werner Heisenberg laid the groundwork for modern quantum mechanics on the German island of Helgoland. Hence, 2025 is the official UNESCO "International Year of Quantum Science and Technology."[1] This study deals with discussions about what quantum mechanics means, in particular, the tensions between a historical materialist approach and the positivist model of Heisenberg and his latest follower, Carlo Rovelli, who declares his model as being in line with the thinking of Alexander Bogdanov.

Figure 1. The author in Helgoland August 2025 at the Heisenberg commemorative plaque

Within the Marxist tradition of Historical Materialism, I argue that every (scientific) form of knowledge is grounded in the social history of humankind. This certainly

1 Unesco: https://quantum2025.org/

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doesn't mean that we witness a linear progression in our understanding and theories. On the one hand, we see the emergence of novel theories and methods in light of societal developments, an approach that got full attention following Boris Mikhailovich Hessen's (1983–1936) famous analysis of Newton (Hessen 1931, 2009 p. 41–202, 2013), a stepping stone for the field of sociology of science. On the other hand, societal catastrophes induce serious drawbacks, such as the Roman destruction of the advanced Hellenist culture (Russo 2004) or crises that heavily hamper research, e.g., the tensions between the semi-religious Stalinists' Diamat and progress made in physics in the former USSR.[2]

In this study, I go back to the fundamental discussions on positivism at the beginning of the 20th century, in particular the old and still relevant discussion between the materialist Lenin and the positivists, in particular Bogdanov.

In order to discuss relational quantum mechanics (RQM), I take the reader through four interconnected steps.

First, I revisit Ernst Mach's positivist, pragmatic empiricism and his influence on socialist thought. Mach inspired followers such as the social-democrat Friedrich Adler as well as the Bolshevik Alexander Bogdanov. Mach's sensory-based philosophy shaped the famous Vienna Circle, the cradle of logical empiricism /positivism. This sets the stage for understanding the philosophical climate in which early 20th-century debates on science and socialism unfolded.

Second, I examine the Lenin–Bogdanov controversy, situating Bogdanov's "empiriomonism" as both a continuation and transformation of Mach's positivism and as a point of departure for later tensions between Marxist dialectics and scientific epistemology.

Third, I outline the conceptual revolutions brought about by quantum mechanics, contrasting Heisenberg's matrix approach with Schrödinger's wave mechanics. I also show how their different emphases on observables, probabilities, and representation shaped the "measurement problem" that still haunts quantum theory.

Finally, I turn to Rovelli's RQM, analysing his rejection of observer-independent states, his reliance on interactional "facts", and his Machian inheritance, before raising critical questions about his positivist constraints, his treatment of measurement, and his downplaying of dialectical dynamics. Rovelli explicitly expresses his appreciation for Bogdanov.

In following this route, I aim to show that the philosophical tensions between materialism, positivism, and relationalism are not merely historical curiosities but remain active fault lines in contemporary interpretations of quantum theory and hence our understanding of nature.

After more than a century of the Lenin-Bogdanov polemic, most contributions on this debate still circle around political debates in the Russian socialist movement, often referring to, but without sufficient knowledge of, modern science. In order to address the merits of this discussion between Marxism and positivism, I have to start with an overview of the issues at stake, that is to say, some epistemology and

2. For a selection of studies see: (Bailes 1978; Medvedev 1979; Graham 1987; Krements͡ov 1997; Josephson 2000; Kojevnikov 2004).

some quantum mechanics, before we can return again to the strife between materialism and positivism.[3,4]

1) Introduction

This study is about the pertinent issue of the extent to which human beings are able to grasp nature, including understanding themselves as natural offspring and subsequently, as a semi-independent part of nature. To do so, an overview of the various wide-ranging ingredients is needed, not to fall into the trap of mono-causal reasoning and simplistic statements or polemics.

I will try to paint the stage in which the debates about the knowability of nature take place. These debates are to a large extent linguistic battles in which the tensions between vernacular and formal (often sign) language play a central role, as we humans communicate among each other in a variety of languages.

I will introduce the star players and will discuss the context and main issues in the debate. I begin with Ernst Mach and then his followers; the empiriomonists on the one side and the logical empiricists (later known as logical positivists) on the other side. Subsequently, I will try to explain the key issues of quantum mechanics, often illustrated with the example of 'complementarity': the idea that we have a mutually exclusive particle or wave 'picture' of atomic phenomena. After this, I will discuss the works of the theoretical physicist Carlo Rovelli as an advocate of the idea that 'reality' is given by relations only.

The following is most and for all, in French kitchen terms, a *mise en place.*

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Below, I will zoom into the issue of how we can understand physics phenomena, in particular those we can handle with so-called quantum mechanics, in a not too technical way. Quantum mechanics is a highly productive descriptive theory, and its intrinsic features are still up for discussion today. Hence, many approaches towards quantum mechanics, also known as interpretations, have continued to fill thousands of pages in science journals and books since the mid-1920s. Miraculously, quantum mechanics 'works', as does Newtonian mechanics, in selected

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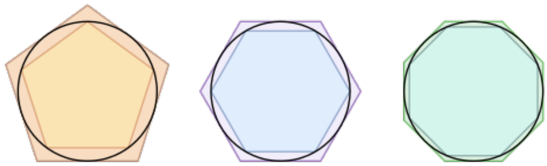
3. Warning: Nowadays, it is customary in academic publications to list as many bibliographic references as possible in the obsessed fashion of counting publications and so-called metrics as sources of perceived importance. In an earlier live, I argued against this data without content and hence I only refer to other works with a reason (important and/or good clear read). I use footnotes, <u>a most important part of a publication for understanding context and merit</u> as entries for further discussion and not as tool for an exhausting nitpicking academic discourse. The interested reader might chose to skip all footnotes on the first reading, and then come back (Kircz 1991; Grafton 1997).
4. As E-books are now becoming a standard knowledge production line, references to page numbers, as usual in printed publications, are lost. This is a serious problem. Hence if no page numbers are given of a quotation, I refer to an e-version of the said work.

environments. The miraculousness of quantum mechanics is that, in contradistinction to traditional (or classical) mechanics, we have no solid, that is to say socially accepted, idea of why it works so well. Hence, most practitioners just use the tools of quantum mechanics successfully without further questioning why they do.

An important feature for the success of a theory is hidden in Archimedes' (of Syracuse, ~287-~212 BCE) method of exhaustion. Best known as the method of finding the area of a curved shape by inscribing in- or outside it a sequence of polygons (one at a time) whose areas converge to the area of the containing shape.



This method of a consequent approximation to a curved object by ever smaller geometrically straight objects is also the basis of calculus (Boyer 2017).[5] A crucial aspect is that the curved continuous functions are so-called smooth, that is to say, without sharp corners, kinks, or breaks. In general relativity theory (GRT), this demand is essential, contrasting with quantum mechanics, which deals with granular objects. The method of exhaustion serves also as a metaphor for theory development: we try to keep within the boundaries of what we can handle, and only at a kink or break, do we find we have to switch to novel methods.

In the following, I also try to tackle the problem of how to combine experimental, phenomenological findings with historically ever more encompassing theories and the ever-changing meaning of the words that we use to describe our findings and theories. Theories come and go, and in this progression, some theories will be abandoned in so-called scientific revolutions or paradigm changes, but in many cases 'obsolete' theories remain operational in those fields where they simply work.[6] This does not mean that a superior theory must include the older one: lock, stock, and barrel.[7]

5. This approach is also close the so-called Finite Element Method in tackling engineering problems.
6. For example: although in the understanding of heat we have a superior deterministic atomic theory, the so-called kinetic theory (heat as the expression of a kind of motion), the professional engineer or plumber still deals with heat flows. Scientific revolutions or evolutions in knowledge are long processes and often, as nowadays with quantum mechanics, the novel insights in a part of research can only claim a total covering of knowledge but are not needed in practice (See also: Cohen 1985, Renn 2020).
7. It is often argued that quantum mechanics is the most basic theory we have and hence, from bottom to top, all other natural sciences can be tackled, in principle, by quantum

Historical materialism is a dynamic approach meant to try and explain social and scientific notions in terms of the social dynamics of contemporary knowledge. Within the context of historical materialism, the famous debate between Lenin and Bogdanov on the role of materialism and Machism (aka empiriocritisism and Bogdanov's own extension, empiriomonism) is still an important debate, all the more because with the publication of translations of Bogdanov's works in English (after a century!), we can scrutinize their merits to better today's understanding.

2) Human Capabilities and their Limits

In discussing human understanding of nature and the roles physics, chemistry, and neurology, etc. play, in building an understanding of nature, we have to start with some elementary notions of the human capabilities to do so.

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We can start with the assertion that humans have a minimum of three -accepted- capabilities that are needed for understanding.

Firstly. Humans have the capacity of thinking; that is to say, consciously reflecting (sensuous) experiences. Thinking is closely related to the notion of self-consciousness, a subject with a long history in Western philosophical thinking and the subject of the recent book by Siyaves Azeri (2025).

Below, I consider thinking as that part of neural activity that allows us to project feelings, experiences, etc., onto mental models, theories as well as bodily activity.[8]

In today's cognitive sciences, the issue of thinking is quite instrumental. As we can measure (carnal) brain activity (which is supposed to harbour the mind), it is a natural next step to try and find out how the pass-ways are between say, hearing a sound and jumping out of my chair or uttering an answer. The cartography of 'neural networks' is a great advance in researching the working of the brain, as seen as a kind of machine, with semi-automatic activity. On top of that, the mathematical models of a 'neural network' prove to be a bonus for developing complicated software that is pitched as a fundamental step to all kinds of artificial (computer assisted) reasoning, even to artificial intelligence.

Secondly, in order to compare, fuse, and analyse various sensory affects, humans need memory. Memory can be simple, as analysed in stimulus response research or more abstract as part of making dynamical associations where we compare indirect but similar-in-appearance

mechanics. The only problem then becomes the computational enormity of such an approach. As I discuss in this paper the issue of quantity ↔ quality transitions becomes crucial.

8. Thinking is not a kind of 'sub-routine' of the human body like a computer programme ("a mental structure as functional architecture") as suggested by some US philosophers such as (Fodor 1983) and (Dennett 1993).

stored thoughts. These non-trivial associations between once-stored thoughts (or, in reduced form, information) is a source for phantasies, sudden insights, eye openers, and explicating intuition. They are also important for developing future thoughts and actions. The memory can also be considered a reservoir for "the zone of proximal development" in Vygotskian terms.[9] Pondering a problem might result in a novel insight by conscious or unconscious comparisons.[10]

Thirdly, in direct connection with thinking and memory, it is human action and activity that fuels and shapes the dynamics of human culture and the ever-increasing wider understanding of nature. In order to connect among members of the species, we need common human languages whose roots might be a result of a co-evolution between our language centre and the capacity of labour, including tool making, by our hands (Wilson 1999). It is the last point in particular that is foundational for the very notion of historical materialism: the notion that human activity in its societal setting is a continuous progression of human culture, where we become able to try and understand how we arrived where we are (biological evolutionary as well as socially), which might enable us to forecast, by setting explicit goals (Woolfson 1982).

Obviously, the most nagging issue is the notion of reality. Here, the various worldviews splinter. In the traditional sense, we are looking for a final truism, the 'objective real' world out there. In biblical terms, it was God, the creator of the heavens and the earth (Genesis 1.1.), who uttered: "Let us make humankind in our image, according to our likeness." If this is correct, then by fiat, humans must be able to find true reality on par with God. The scientific question is then how? In the Kantian philosophical system (Kant 1998), which is narrowly inspired by Newtonian mechanics and accepts unexplained notions such as gravity, we can only ever expand our understanding, which in the realm of reason becomes a '*ding an sich'*, a thing in itself; the bottom will never be reached. In a historical view of knowledge, such as in historical materialism and certainly in the ideas of Mach and Bogdanov, reality is a moving target depending on how we experience and define it in a certain context. If we experience a thing tangibly, we consider it real existing; this is a cornerstone of Mach's approach. However, we must take the following into account: a) the tactile thing can have various names depending on the context: a teacup for a tea drinker can be a donut for a

9. Lev Semyonovich Vygotsky (1896–1934), was a Marxist trail-blazer on psychological development in children and co-creator of the framework known as cultural-historical activity theory.

10. Well personalised by Carl Barks's (1901–2000) inventor Gyro Gearloose and his small robot helper whose lightbulb head switches on by a novel idea, in the Walt Disney's Donald Duck cartoons.

student of topology, b) in Marxist materialism, a thought (or in Ilyenkovian terms, a socialised Ideal)[11] as a product of human thinking can often also experienced as real, even if it does not (yet) reaches simple sensory status and remains in the state of a theoretical tool, such as the notion atom was seen by Mach. Here we are confronted with the realisation that the more we know, the more multifarious the 'thing' becomes. Certainly in quantum mechanics, pinning down a 'thing' becomes difficult, to say the least, as we will see below. In a materialist Marxist context, we accept, contrary to Mach, as Lenin phrases it: objects can exist in themselves, or outside the mind; ideas and sensations are copies or images of those objects (Lenin 1908 26).

This statement demands precision. One can say that objects exist which we cannot sense directly and for that reason might be even nameless. A modern example is 'Dark Matter'. Our best theory of gravitation suggests its existence based on our measurements of cosmological objects. Hence it has the same status as the atom at the end of the 19th century. We have a name for an object whose existence we infer from combinations of known situations, but we cannot yet declare that it has more than a theoretical existence.

Importantly, we have to take measurement devices into account when we talk about sensations. These devices transform physical effects into human sensible form. Obviously, such devices, like our own senses, don't guarantee a complete picture but might only present an aspect. Lenin's 'copies' are always partial.

We deal here with representing a real (observable) thing without demanding that one representation is more fundamental than another. It is important to state that the 'thing' is still objective in the sense that it can exist outside the human being and hence, often even before humankind started roaming the planet. I contend that the common notion of 'reality' is pure metaphysics. Obviously, there is a 'world' without humankind. But it is us—humankind—that gives this world a name. That name is reality in the meaning of 'out there' in the sense that we can communicate this notion productively with other humans. The materialism of Marxism is a philosophical materialism, in contrast to the 18th-century belief of only elementary units of stuff. That belief posed the question of what stuff or matter is. The further we grasp nature, the more the notion of stuff is shifting. In physics, we talk of mass, a more flexible and well-defined notion: the resistance to acceleration. Materialism in Marxist's sense is the understanding that there are things outside humanity and that this can be investigated socially, will be named or even defined, and subsequently used for theory building, but, and this

11. Evald Vasilievich Ilyenkov (1924–1979) was the most important post-Stalinist Marxist philosopher. See also volume 3 of the journal *Marxism&Sciences* for a centennial appreciation. https://marxismandsciences.org/all-volumes-issues/

is essential, it can never be a final given, this in contradiction of the Kantian *ding an sich*.

As humans use nouns for things and things become ever more encompassing with the growth of knowledge, the content of the meaning of a notion is flexible. That can be downwards, e.g., in the case of the word "atom," from the smallest Democritian particle to Quarks in modern particle physics, or upwards, from earth to the cosmos as we understand it now. The fundamental tension in the philosophy of science is the situation in which we, at one point in history, give something a name (or sign), subsequently use this name as a 'building block' for a theory, and in the next phase, our experiences outgrowth that very notion and then we have to split the notion or merge it with others. A kind of triple jump game, in more dimensions.

An important example is the now-popular notion of 'information', which has gotten traction in the attempt to understand quantum mechanics. As we will see below, if an experiment (e.g., looking at the moon) gives some results, the theory tells us that only in the measurement can we talk about objects: the famous question Einstein asked Abraham Pais (1918–2000): "…whether I really believed that the moon exists only when I look at it. The rest of this walk was devoted to a discussion of what a physicist should mean by the term 'to exist' (Pais 1979, 907)." Information seen as a countable notion about a named object becomes a measure of reality. There is no yes or no about an object we happen to name 'moon'; the only question becomes if we have information about that object, one way or another, which with we can calculate.

3) Why Rovelli and Bogdanov?

In this section, we introduce the heroes of our study on the strife between historical materialism and positivism.

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As Carlo Rovelli stipulates:

> *"Precisely the issues debated by Lenin and Bogdanov have returned in contemporary philosophy" (*Rovelli *Helgoland)* [12]

Carlo Rovelli (1956- ....) is a theoretical physicist, editor in chief of the prominent journal *Foundations of Physics*, and an avid populariser known for his many books and presentations (also on internet channels). Rovelli is a specialist in two new approaches in theoretical physics: loop

12. Volume 4 issue 1, of *Marxism & Sciences*, deals with the legacy of Bogdanov https://marxismandsciences.org/issue-8/. Bogdanov (Alexander Alexandrovitsj Malinovski, 1873–1928), was an important leader of the Russian Social Democratic Party (Bolshevik), a medical doctor by profession (Krementsov 2011), a prolific author, and the inventor of tektology, the precursor of system theory and cybernetics.

gravity, dealing with the attempt to merge gravity with quantum mechanics, and his relational quantum mechanics (RQM) interpretation.[13]

Rovelli, next to being a prominent scientist and science educator, is a socialist-leaning person, a student activist in the 1970s, and a peace activist (Rovelli 2023c). He had read Lenin's *Materialism and Empirio-criticism* (Lenin 1908) as a young man, and hence he clearly fits the pluralistic group of Western socialist physicists like Ernst Mach (1838–1916), Friedrich Adler (1879–1960), Albert Einstein (1879–1955), Paul Langevin (1872–1946), Frédéric Joliot-Curie (1900–1958), David Bohm (1917–1992), and Jean-Pierre Vigier (1920–2004).

Rovelli's popular book, *Helgoland*, is named after the German island where Werner Karl Heisenberg (1901–1976) laid the basis of the matrix mechanics interpretation of quantum mechanics (Rovelli 2022a). Rovelli dovetails his Heisenberg story of the history of the so-called 'Heisenberg picture' of quantum mechanics, formally named 'matrix mechanics', with the 'empiriomonism of Bogdanov (Rovelli 2022b, 2023b p312 and p320), and he quotes negatively from Vladimir Lenin's (Vladimir Ilyich Ulyanov, 1870–1924) harsh critique on Bogdanov in his *Materialism and Empirio-Criticism* (Lenin 1908).[14]

Bogdanov was a proponent of Ernst Mach (Ernst Waldfried Josef Wenzel Mach, 1838 -1916). So, we have to hark back to Mach, and subsequently to Lenin's attack on the Mach school, and further we have to try and find out what are still the pertinent issues in the discussion for our current understanding of the relationship between Marxism and the natural sciences. In particular, since Bogdanov's works are now finally in the process of being properly translated into English, his translator correctly concludes in a recent paper:

> As far as cultural studies and systems and organisational science are concerned, Bogdanov is of great contemporary importance, but the relationship of his first works of scientific philosophy to his views on Proletarian Culture and his vision of universal organisational science has yet to be investigated (Rowley 2024).

4) Physics and its Language

In this section, first, I will give some background on physics as an art and science for understanding nature (the physical nature of which humans are an offspring).

13. Obviously, Rovelli's popular works doesn't show the deepness of his academic papers. Hence, attention will also be given to those works.

14. Note that Lenin's polemic book was not a 'best-seller' upon publication. But due to the degeneration of the young Soviet state, in the late 1920s, the book became a catechism of so-called Diamat, the Stalinist state philosophy and hence also the 'whipping boy' of all anti-communists.

In doing so, we need an understanding of the language we use. There is a sliding scale of semantics, from local vernaculars to the well-defined notions of a formal theory.

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More than often terms used in a theory—for example 'relativity' in gravity theory (which actually means invariance to changing coordinate systems, that is to say the value of something does not depend on the type of coordinating)—get a completely different meaning in popular sloppy speech, which leads to not only misunderstandings about the theory at stake, but often also generates blatant nonsense in the use of scientific technical terms.[15]

Words: nouns and verbs, are used as pertinent expressions for things in action. Contrary to tactile communications, words can be communicated independently of place and time; they are the bricks for theory building and social cohesion: "*It's only words and words are all I have.*"[16]

In the course of history from natural philosophy to modern theoretical physics, the language of physics is more and more pinched to unambiguously defined notions following the 'iron' rules of some branch of mathematics. This means that symbolic (mathematical) sign languages can induce experimentally confirmable results (the stone falls downwards), but have the negative effect that such signs are too restricted to encompass full physical reality. The mathematics used by physicists is full of approximations that are often fundamentally ad odds with formal logic (Aristotelian style), which after all is defined by tautologies and has no place for dynamic change or time. Simple change, such as the (human) notion of velocity, is always—as Rovelli emphasises—a change of something in comparison to something else (velocity is distance measured in meters travelled divided by the ticks of a clock).

There are more notions and emotions than words, and hence, terms have different meanings in different contexts. In this paper we use the term 'nature' for the physical, material, totality of the universe. So-called 'human nature' deals with the evolutionary results of human social behaviour. For a discussion on Karl Marx and human nature see Geras (1983).

Talking about words as representation of meaning, immediately shows the tension between what is properly called in German v*erstehen* (understanding in the sense of feeling) and *begreifen* (comprehend, grasp)*;* in English, both notions are conflated to understanding. In the following, we will use understanding (*verstehen*) as the human feeling

15. Example from biology. "The psychological DNA of many founder-leaders—characterized by self-reliance, creativity, and deep emotional investment in their businesses—sets them apart from traditional CEOs, whose acquired expertise and pattern-recognition skills are more suited to incremental growth." *Harvard Business Review* May/Jun 2025 (It is not the present author's ambition to promote the names of hard-working business pundits).

16. The Bee Gees 1968, *Words*: https://www.youtube.com/watch?v=X-NakRJDyeU

of closeness to what has been said, whilst we use grasping in situations where we deal with more formalised operational understanding, such as in logic, algebra, or geometry.

It is important to understand (*Verstehen*) that in experiencing situations (any kind) we automatically try to fit these experiences in the stock of knowledge we already master. In that sense, we (socially) construct an understanding (comprehension, grasping) which is fitted in formal and/or scientific models and theories. Models and theories that become a reservoir for advancing (or frustrating) new knowledge. The first thing we normally do is to try and mould novel experiences into existing explanations of situations.

This explaining by example or analogue is the standard way of introducing new phenomena or theories to an outsider (into his/her zone of proximal development). A typical example is given by the American physicist David Mermin in his collection of highly readable essays (Mermin 1990).

> Mermin introduces: "The Strong Baseball Principle insists that the outcome of any particular game doesn't depend on what I do with my television set, that whatever it is that happens tonight in Shea Stadium, will happen in exactly the same way, whether or not I'm watching on TV." (Mermin 1990, p.100)

Obviously, such an explanatory metaphor only works if the reader lives in a society in which 'games' in a 'stadium' and 'television' are household knowledge.

That is to say, if our current understanding (grasping) is not (yet) ready for novel situations, we only have two options: a) an experiment that fully negates the current understanding; debunking a theory, or b) developing a new systematic theory that gives a novel sense of 'obviousness' for the situation. In popular terms, we call this a scientific revolution. It is here that we reach the twilight zone between scientific theories, visionary hunches, metaphysical believes, and obscurantism.

A disturbing element in the conscious development of novel ideas is the present-day flood of 'information' from the ever increasing number of serious (but not necessarily relevant) academic investigations,[17] which are intended as helpful popularisations but might result in complete nonsense.

This makes it difficult to present arguments about the validity of the sciences and humanities in a language that embraces both the essence

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17. The Dutch University Rathenau Institute keeps a meticulous track of all Dutch scientific publications and relates them to 20 high productive nations as benchmark, as if productivity and citation scores are an intrinsic measure of insight and quality: https://www.rathenau.nl/en/science-figures/output/publications/scientific-publications-international-benchmark-wos

of the scientific investigations against frivolous popularisations and counter dangerous gibberish.[18]

However, with the increase of the amount of knowledge, the volume of unknowns increases even more rapidly, this increasing ignorance forces us to ever reconstruct permanently in terms of both understanding and grasping, the world 'out there (but including our own species).' As said, this is a central tenet of historical materialism. For the discussion of the larger growth of ignorance compared to increasing knowledge see e.g.: Tyson (2005), Firestein (2012), Kircz (2024).

Example: We now realise that the pertinent Biblical statement:

> "Then God said, "I give you eve They will be yours for food. And to all the beasts of the earth and all the birds in the sky and all the creatures that move along the ground—everything that has the breath of life in it—I give every green plant for food...And it was so" (Genesis 1:29)

leads to a complete ecological disaster. In order to save the very existence of our species, we have to act, and in that act, we'll have to change the runaway deterioration of human foodstuff and the physical consequences thereof (obesity, cancers, etc.). Which implicitly means a change in the human biological and social 'make-up.' Nevertheless, tens of millions of people still defend 'the words of God' as final, closed, inexorable truisms.

In the following, I discuss the merits of physics as an example of the broader natural sciences. Subsequently, I discuss the 'art of knowing', also known as epistemology, including the debate between positivism and empiriomonism on the one side and Marxian materialism on the other side.

After this ground work, I will focus on Rovelli's relational quantum mechanics (RQM).

5) On the Role of Language and Naming as Stepping Stones for Theory.

In this section, I deal with the difficult issue of reducing understanding with fixed notions to ease inter-human communication. After discussing the problem of naming phenomena and theoretical notions, we enter the field of physics, and subsequently quantum mechanics.

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18. On February 13th 2025, Robert F. Kennedy Jr. was officially sworn in as boss of the nation's leading scientific public health department, in a ceremony at the White House. In his speech he stated: "For 20 years, I'm up every morning on my knees and praying that God would put me in a position where I can end the childhood chronic disease in this country." "God sent me President Trump." "And I've told you before," he said, addressing Trump, "I genuinely believe that you are a pivotal historical figure, and you are going to transform this country." Source: All US new agencies.

Obviously, naming things and relations between things (and experiences) fluctuate enormously between cultures and their level of technology. Translations and interpretations of spoken and written languages are millennia-old crafts (Delisle and Woodsworth 2010), and interpreters are still a fundamental part of international meetings. Automation of translations is presently seen as a financial holy grail in the semiconductor industry. However, where standard phrases can be dealt with in statistical models (aka AI), more literary and not-yet-standard words and expressions are still an unsolved issue.[19] As mentioned above, in one language, a subtle difference in the meaning (formal and emotional) often cannot have a one-to-one translation into another language.[20,21]

The belief in the written or spoken words of important persona is important, as in popular science writings, such as the many (well written) books by Rovelli. The reader gets some feeling of what it is all about and even might use terms used (e.g., expressions such as ‘a quantum leap’ for a big step forward, whilst the quantum is the smallest unit of energy of a certain frequency, etc.). In that sense, Rovelli’s (in the wake of Bogdanov) notion of ‘relational’ certainly rings a bell, but this doesn’t mean that the intrinsic meaning becomes clear. As said above, in all explanations of complicated situations, metaphors, referring to well understood situations, are of great value, but exactly here, the tension between well-defined terms and linguistic pragmatics comes to the fore.[22] We will deal with this below as well.

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19. It is tension between understood notions and there (always approximate) translations in other languages and the craft of using large ‘data-sets’ to suggest translations by statistics.
20. See e.g. the glossaries from German to English and *vice versa* in the latest English translation of Kant’s *Critique of Pure Reason*, pp. 757–774. (Kant 1998), and the translator notes in Hegel’s *The Science of Logic* (Hegel, 2010).
21. An example is how to translate Marx’s German notion of *Arbeit* in English: labour or work? Labour is a manifestation of the expenditure of labour-power in creating (use-) value. It has a clear anthropological flavour. If in the process of commodities exchange, we reduce the notion to a countable reduction: labour-time spend, then work seems more appropriate. Work in mechanics is well defined as the energy transferred to or from an object via the application of force along a displacement, it is a scalar quantity with only a magnitude (the Joule). It is ‘neutralised.’
22. Due to the insane policy of reducing the contents and the lead time of education in an ever more complex world and an ever increasing human life span, the divide between the humanities, the natural sciences, and the mathematical reductions of knowledge to countable so-called data makes more general perspectives on where to go, increasingly difficult. Fred Engels was one of those ‘old fashioned’ intellectuals who tried to catch up with the vibrant scientific developments in the 19th century (Kircz 2022). Karl Marx, in his turn, enjoyed playing with the riddles of calculus in his drive to describe the dynamics and cycles of the economy (Marx 1983). In our time, in all fields we see a kind of twigging, where all knowledge, theoretical as well as practical, is spread out into independent occupations, each with its own specialisation, vernacular, and rules. The flip side of this is an explosion of popular science books as well as science fantasies. Happily there are also many excellent educational and critical (online) outlets whose drive is go beyond simplistic notions. Unavoidably, the religion industry is also present with a plethora of web-sites

A serious issue is the understanding of the difference between starting with (semantic) notions as nouns and their interactions (relations) by the use of verbs or to take verbs, describing interactions or motion, as starting point. Nouns can be collected in so-called synsets (see: https://wordnet.princeton.edu/), a group of words that are (in some aspects) equivalent in meaning and hence might be interchanged to emphasise a particular focus. The intrinsic fluidity of verbs makes it almost impossible to create such a categorisation.

Note that all serious thinkers in physics deal with the issue of language. Rovelli's hero, Heisenberg, whose philosophy is inspired by Johann Wolfgang Goethe's (1782–1832) idea of a hierarchical order of reality, phrases the issue as follows:

> The vagueness of this language in use among the physicists has therefore led to attempts to define a different precise language which follows definite logical patterns in complete conformity with the mathematical scheme of quantum theory…
>
> It is especially one fundamental principle of classical logic which seems to require a modification. In classical logic it is assumed that, if a statement has any meaning at all, either the statement or the negation of the statement must be correct. Of "here is a table" or "here is not a table", either the first or the second statement must be correct."Tertium non datur," a third possibility does not exist. It may be that we do not know whether the statement or its negation is correct; but in "reality" one of the two is correct. In quantum theory, this law "Tertium non datur" is to be modified. (Heisenberg 1958, 181).

However, in an earlier lecture of the same lecture series, Heisenberg stressed the nagging claim that quantum mechanics is a closed system and posits:

> One may hope that the combined effort of experiments in the high-energy region and of mathematical analysis will someday lead to a complete understanding of the unity of matter. The term "complete understanding" would mean that the forms of matter in the sense of Aristotelian philosophy would appear as results, as solutions of a closed mathematical scheme representing the natural laws for matter (Heisenberg 1958, 166).

In which he clearly adheres to the idea that we can reduce physical notions to formal symbols into a formally complete mathematical structure. Obviously, such a claim and the excluded middle problem can be

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and, unfortunately, the Left is left out in its often highly academic discussions about the foundations of the sciences. The great challenge is not to use scientific ideas, theories, and findings as proof of pre-existing ideologies, but to integrate these advances into a further understanding (*verstehen*) of the human condition. This is contrary to the so-called Diamat approaches of the Stalinist tradition, which have as goal, proving that all scientific progress fits the Procrustes bed of a few (in fact static) laws that pretend to describe a dialectical dynamics.

seen as ingredients for the probabilistic interpretation of the matrix mechanics (see also below).

In a logical mathematical form, symbols are fixed, and change or fluidity is not in the vocabulary of formal logic. Change is introduced by, e.g., a measure of time and the change of a property of an object (represented by a sign) as a function of time; sign Θ (representing object A) has position (or electric charge) of value X, but on a later time (or elsewhere) it has value Y. It is here that the breakthrough of the calculus enters science. In calculus, we can reduce the notion of velocity, as defined by the stretch of distance traversed in units of time, to an understanding of the velocity of an object at a single mathematical point.[23]

Importantly, the meaning of verbs is less ambiguous than nouns, and lexicographically, verbs are less easy to compare mutually as nouns can be. An interesting approach to the 'fluidity' of verbs in contradistinction to the relative fixity of nouns, is given by the theoretical physicist and founder of the causal interpretation of quantum mechanics, David Joseph Bohm (1917–1992). In his essay 'The rheomode—an experiment with language and thought' (Bohm 1981, chapter 2), Bohm states:

> All of these are regarded as sides or aspects of an unbroken and undivided whole movement, which are closely related, both in function and in content (and thus we do not fall into a fragmentary division between our 'inward' mental activities and their 'outward' function). Evidently, this use of the rheomode fits very well with the world view in which apparently static things are likewise seen as abstractions of relatively invariant aspects from an unbroken and undivided whole movement. (Bohm 1981, 46)

> ...the world view implied in the rheomode is in essence that described [in the first chapter of the book -JK], which is expressed by saying that all is an unbroken and undivided whole movement, and that each 'thing' is abstracted only as a relatively invariant side or aspect of this movement. It is clear, therefore, that the rheomode implies a world view quite different from that of the usual language structure. (Bohm 1981, 47)

So, Bohm, in his thinking, is close to an idea of 'global' relations as a basis, which we can compare with Rovelli's notion of 'relational.' As we will see, Rovelli doesn't address this fundamental idea of Bohm and sticks to Heisenberg's positivism.

So, basically the advance of a global culture that merges formal logical, scientific, as well as social, philosophical, and emotional languages has two related avenues.

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23. In Marx's and Engels's time this was not yet fully comprehended and hence we witness their struggle with the idea that instead of a limit we deal with a fined division of zero by zero, which is not defined. (Marx 1983, Engels 1873–1882/ 2010). Unfortunately, still Marxists of repute hark back to these texts of the masters, without entering the key issue of continuity versus discontinuity, and without addressing modern mathematics.

A) On the one hand, the drive to one *Lingua Franca;* Latin in the previous centuries in the 'western world' and presently, what we call, international English. Obviously, such drive is at odds with the striving for local or ethnic identity and the uniqueness of situations and objects: how many kinds of *begreifen* describe the human v*erstehen* in various circumstances? Every culture has its own way of expressing emotional feelings and sensory experiences. It is the role of the sciences to bundle the essence of these experiences into well-defined notions to further new knowledge and emancipation. It would go too far in this paper to discuss the famous Sapir–Whorf hypothesis, which in its strong form suggests that linguistic categories limit and restrict cognitive categories. But certainly, notions in physics theories have clear boundary conditions. Our present discussion is related to the notions of what we mean with here and now, as well as with the mathematical approach by using axiomatic declarations of objects and their relations (such as energy and mass).[24,25]

The interest of Mach's logical-empiricist offspring shifted from the analysis of sensations towards logical analysis of language in their ambition to create an all-encompassing *unified science* based on the *scientific world conception,*[26] based on logic and well-defined notions.

Rudolf Carnap (1891–1970), one of the members of this philosophical current, was an avid supporter of Esperanto as a universal language. It is also the basis of the young Ludwig Josef Johann Wittgenstein (1889–1951) *Tractatus Logico-Philosophicus (*original title *Logisch-Philosophische Abhandlung*, 1921) (Wittgenstein 1999) which was a bombshell for the Logical Empiricist's Vienna Circle. The declarative mathematical logical structure resulted in the famous final sentences:

> 6.522: There is indeed the inexpressible. This *shows* itself; it is the mystical.
> 6.53: The right method of philosophy would be this. To say nothing except what can be said, *i.e.* the propositions of natural science, *i.e.* something that has nothing to do with philosophy: and then always, when someone else wished to say something metaphysical, to demonstrate to him that he had given no meaning to certain signs in his propositions. This method would be

24. Example. If we take the 2nd law of Newton: F=Ma, which says that F(orce) equates the multiplication of M(ass) times (a)cceleration. These three notions are co-defined; acceleration (change of a linear trajectory) is given by the applied force divided by the mass of an object. However, in general relativity theory, we can argue that acceleration is absolute and hence more fundamental than the others, which become derived notions.

25. Take the notion of mass. It is interesting to note that Ernst Mach takes Newton's third law, 'action equals reaction,' as basis of the definition of mass, contrary to Newton who stipulates that all bodies have masses: a quantity of matter (stuff). For Mach, matter as such cannot be perceived by the senses, and certain assertions such as the conservation of matter cannot belong to science since knowledge of them cannot be explicated (we experience elements! See also further). All those bodies are bodies of equal mass, which, mutually acting on each other, produce in each other equal and opposite accelerations (Mach 1960, 264ff). For a discussion (Koslow 1968).

26. For their highly ambitious 'manifesto' see (Vienna Circle 1919).

unsatisfying to the other—he would not have the feeling that we were teaching him philosophy—but it would be the only strictly correct method.
7. Whereof one cannot speak, thereof one must be silent.[27]

Wittgenstein's conclusion dovetails with the idea that in order to understand the world, we need a repertoire of well-defined notions and based on that well-defined sentences. The last being the cornerstone of Carnap's (Paul Rudolf Carnap 1891- 1970) investigations in protocol sentences.
For an historical materialist, this is pure idealism. Human activity and action are not here the starting point but the human projection of these actions and their results in fixed—human invented—formal notions. Obviously, the process goes two ways, in the dialectics of new experiences formulated into new linguistic knowledge; both experience and name stimulate each other creatively. It is in the Hegelian tradition that the 'helix' of entangled experimental results and ever-developing theory, leads ultimately to the abstract idea (the incarnation of a theory of everything), whilst in Marxian terms, the ever-growing unknown will never reach such an ultimate truth, due to ever novel insights, findings and knowledge. [28]

As argued above, the almost religious reliance on some forms of logic as a closed system restricts entering the unknown. Logics feels safe for the sake of present-day mathematics. However, in physics, chemistry and biology, just to name a few fields, unexpected findings are omnipresent. We are constantly rebuilding our knowledge and understanding. But, to use a metaphor, we cannot do this with a limited number of Lego bricks (or in the old days Meccano). One of the founders of logical-

27. 6.522 Es gibt allerdings Unaussprechliches. Dies zeigt sich, es ist das Mystische.
6.53 Die richtige Methode der Philosophie wäre eigentlich die: Nichts zu sagen, als was sich sagen lässt, also Sätze der Naturwissenschaft—also etwas, was mit Philosophie nichts zu tun hat –, und dann immer, wenn ein anderer etwas Metaphysisches sagen wollte, ihm nachzuweisen, dass er gewissen Zeichen in seinen Sätzen keine Bedeutung gegeben hat. Diese Methode wäre für den anderen unbefriedigend—er hätte nicht das Gefühl, dass wir ihn Philosophie lehrten—aber sie wäre die einzig streng richtige.
6.54 Meine Sätze erläutern dadurch, dass sie der, welcher mich versteht, am Ende als unsinnig erkennt, wenn er durch sie—auf ihnen—über sie hinausgestiegen ist. (Er muss sozusagen die Leiter wegwerfen, nachdem er auf ihr hinaufgestiegen ist.) Er muss diese Sätze überwinden, dann sieht er die Welt richtig.
7 Wovon man nicht sprechen kann, darüber muss man schweigen.
(https://www.wittgensteinproject.org/w/index.php/Logisch-philosophische_Abhandlung#)
28. As F. Engels comments in his introduction to volume 3 of Capital: "….They rest on the misunderstanding to the effect that Marx seeks to define where he only explains, and that one can generally look in Marx for fixed, cut-and-dried definitions that are valid for all time. It should go without saying that where things and their mutual relations are conceived not as fixed but rather as changing, their mental images, too, i.e. concepts, are also subject to change and reformulation; that they are not to be encapsulated in rigid definitions, but rather developed in their process of historical or logical formation." (Marx, 1993 103)

empiricism, Otto Karl Wilhelm Neurath (1882–1945), famously invented his boat metaphor (which counts three versions):

> "We are like sailors who are forced to totally reconstruct their boat on the open sea with beams they carry along, by replacing beam for beam and thus changing the form of the whole. Since they cannot land they are never able to pull apart the ship entirely in order to build it anew. The new ship emerges from the old through a process of continuous transformation." (Neurath 1913),

As a good social democrat, the image perfectly emphasises his aversion to abrupt changes and the idea of sudden progress.[29]

The sciences, according to Neurath, could only advance into a needed unification by positive knowledge and no-way by introducing any 'metaphysical' notions. This neo-Kantian credo is in opposition to Evald Vasilievich Ilyenkov (1924–1979)'s notion of the Ideal, where notions, not yet ripe for formal logic or other fixed meaning, serve as fuel for progress (Ilyenkov 2014).

Constant new additions are necessary to keep track of all these novel findings, as well as the re-evaluation of our past. Only after the fact can we try to reformulate our findings in a straightjacket of (ever new) mathematics, with new internal dynamics that can suggest new findings, until again we are entering the unknown.[30]

The understanding of a situation as a whole is directly influenced by the perspectives and background assumptions (ideologies) of an individual or social group. This is called theory-ladenness. But it is not only theory but certainly also method- or technology-ladenness.

Playing with LEGO does not have a one-to-one relation (homomorphism) to playing with Meccano. In my opinion, it is also for that reason that Wittgenstein dropped out and reinvented himself in his later pragmatics writings. Hence, different representations will have different upshots, and it is a serious question whether we will be able to bring them under one umbrella. A well-known example is the centuries-old debate of whether light is a wave or a stream of particles and its 'transcending' into the notion of a photon. However, without a yet-clear theory of how, why, and when both—complimentary views —particle or wave representations take the stage, and the transcendence of these two 'views'

29. It is also in line with Niels Bohr's opinion that quantum mechanics must be 'hooked' to classical physics (correspondence principle), which is different from the idea that two independent theories can reach the same results.
30. Think about the introduction of matrix calculations in quantum mechanics and curved space in general relativity theory, which enabled big steps forward in stratifying (and immediately constrains) our experience projected in formalised language.

encompasses a totality of experiences.[31] A well-written, solid but not-too-technical treatise on 'what is light' is given by the historian of science (Hentschel 2018).

In the same vein, we reach the issue of the two types of physical theories as suggested by Albert Einstein in a short contribution to *The London Times* after the experimental confirmation of his general relativity theory (Einstein 1919, 1920). Here, Einstein makes a famous suggestion that we have two types of theories in physics, one that has ever since been discussed in the literature on the philosophy of physics:

a) Constructive theories:

> "They attempt to build a picture of the more complex phenomena out of the materials of relatively simple formal scheme from which they start out. Thus the kinetic theory of gases seeks to reduce mechanical, thermal and diffusional processes to movements of molecules—i.e., to build them up out of the hypothesis of molecular motion."

b) Principle -theories:

> "These employ the analytic, not the synthetic, method. The elements form their basis and starting point are not hypothetical constructed but empirical discovered ones, general characteristics of natural processes, principles that give rise to mathematically formulated criteria which the separate processes or the theoretical representations of them have to satisfy. Thus the science of thermodynamics seeks by analytical means to deduce necessary conditions, which separate events have to satisfy, from the universal experienced fact that perpetual motion is impossible.
>
> The advantages of the constructive theory are completeness, adaptability, and clearness; those of the principle theory are logical perfections and security of the foundations."

For Einstein, the special theory of relativity, which was built on two principles, was a prime example.[32] Rovelli intends to pose this relational

31. Famous is the defence of the idea of a complementary view of natural phenomena by Niels Bohr's colleague Léon Rosenfeld (1904–1974) in terms of 'Marxist' dialectics. Interestingly, Rosenfeld was an aggressive enemy of David Bohm's Marxist inspired-causal quantum mechanics. (Rosenfeld 1953, Jacobsen 2007)).

32. 1) The laws of physics are identical in all inertial frames, or, equivalently, the outcome of any physical experiment is the same when performed with identical initial conditions relative to any inertial frame.
2) Light signals in a vacuum are propagated rectilinearly, with the same speed c, at all times, in all directions, in all inertial frames (Rindler 1990, pp 7–8).
An inertial frame is a frame of reference in which objects exhibit inertia: they remain at rest or in uniform motion relative to the frame until acted upon by external forces. In such a frame, the laws of nature can be observed without the need to correct for acceleration. In that sense, our globe and we are one inertial system, otherwise no hat will stay put while walking.

quantum mechanics as a principle theory.[33] One might also consider this as a kind of quantity ↔ quality transition in which a mature constructive theory can be transposed into a formalised principle theory by stipulating novel comprehensive analytic principles.

As discussed above, in the practical world of physics research, we see an ever to and fro between the two approaches. It can be argued that constructive theories are input for establishing principle theories, and these approaches have a mutually (if you want dialectical) relationship. This is also clear as reported by the young Heisenberg on this positivistic worldview in his discussion with Einstein (Heisenberg 1972, chapter 5. See also below when we discuss quantum mechanics).

6) Physics

In this section, I focus the above discussions on physics, a field that often is a reference for other fields of knowledge and a *Fundgrabe* for metaphors.

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To understand fundamental discussions in physics and their ramifications for other fields, we have to know the way physics tools are developed and used. The prime question (not only in physics) is always how we describe change in such a way that we not only understand where we are now (retroactive causality) but more importantly, how we forecast where we are going and more precisely how we can steer our journey forward. That was also the basic idea of scientific socialism against utopian dreams.

Although the above sentences sound reasonable, it contains notions that must be clarified. It starts with the most questionable terms: here and now. Everybody understands these terms in normal speech. But the issue of here and now needs further analysis before we fully understand our notion of then and there.

Here and now suggests that we can start our investigation with a situation of stasis. "But wait a moment," the now is never the same as "time flows on." Here is also a questionable notion, because it suggests a fixity in relation to an environment which also "flows in time". Below, I will try and discuss these terms, on which many studies are published and are fundamental in grasping relations. Relations between observations, as well as relations between physical phenomena and their 'mapping' onto coordinates and measurements.

The two most fundamental analytic notions in the human relation with nature are distance (the measure of here or location) and time (the measure of change). We move an arm or walk and experience a freedom

33. A thorough but technical paper on this often-discussed suggestion of two types of theories and their implications is given by (Giovanelli 2020).

of motion, which we call space. We make this operational with the notion and measure of distance (measured by common units like a foot or a thumb). We experience change of everything inside (the feeling of hunger) and outside ourselves (traffic, water waves). Because, biologically, we do not have the capacity to compare exactly previous situations with the now, we have to deal with a 'storage' and a common measure. The only - not very precise - 'biological recorder' is our memory, most presumably a part of our nervous system, in particular the hippocampus and other related structures in the brain. [34]

The change in recall from this storage can be measured, and hence compared, by recurrent phenomena, from our heartbeat, via planetary motion, towards atomic clocks.

Or to quote Wittgenstein again (Wittgenstein 1999):

> 6.3611 We cannot compare a process with the 'passage of time'—there is no such thing—but only with another process (such as the working of a chronometer).
>
> Hence, we can describe the lapse of time only by relying on some other process. Something exactly analogous applies to space: e.g. when people say that neither of two events (which exclude one another) can occur, because there is *nothing to cause* the one should to occur rather than the other, it is really a matter of our being unable to describe *one* of the two events unless there is some sort of asymmetry to be found. And *if* such an asymmetry *is* to be found, we can regard it as the *cause* of the occurrence of the one and the non-occurrence of the other.

The same issue of coordination is given by Bogdanov in 1903 in his 'The Ideal of Cognition (Empiriomonism of the Physical and the Psychical' . Published in (Bogdanov 2020 p22):

> Abstract space and time are characterised *by the removal of all contradictions of physiological space* and time from them in order to *harmonise* experience, to coordinate its different parts. This is achieved by removing the heterogeneity of physiological space and time, by bringing continuity into them, and by mentally broadening them beyond the boundaries of any given experience.

In other words, back in 1905, Bogdanov's *Empiriomonism, Essays in Philosophy, Books 1–3* (Bogdanov 2020) defends the *reduction* of human active experiences to abstract notions, which is normal in the history of physics, as a mental model that fits contemporary mathematics. Note that Bogdanov considered space and time as Newtonian absolute 'things.' In 1919, with the invention of general relativity theory, the big step was made where the given experience of three-dimensional space

34. See e.g.: https://qbi.uq.edu.au/memory/where-are-memories-stored and for a nice cartography:https://www.ninds.nih.gov/health-information/public-education/brain-basics/brain-basics-know-your-brain

plus time (so-called 3+1 dimensions) was promoted into a four-dimensional space-time theory, to give a proper description of a positive experience of change.[35] As a consequence, absolute time and absolute space, as the sides of a kind of container for physical processes, were abandoned.

The big issue is how humans can explicate stored information (in not yet understood form) in language.[36] Although there are more and more investigations that show that animals learn from each other, at present, we are the only species that make memory consciously operational in shaping our environment. In other words, whilst animals can only learn how to crack a nut, we can learn how to plant trees, harvest their nuts, process them with machinery, and publish studies on the ecological aspects of, say, hazelnut plantations for producing a popular hazelnut cocoa spread. The qualitative step made by humans is that we not only learn, but implement this learning in social action.

By overcoming this physical lack of comparison, we use representations in the form of pictures, texts, and recordings.[37]

The most obvious stepping stones in making change operational are the logbooks of recurring situations, such as dawn and dusk or our heartbeat. More elusive sensory experiences, such as smell and flavour, can be memorised (and compared, although worse than many other animals). However, we (humans) don't have an immediate measure for these sensory impressions like a foot or heartbeat. Here we encounter a fundamental issue of, call it, analogue comparison (this rotten stuff smells like dog shit, this view reminds me on youthful summer vacations). This in contradistinction to the Giant African Pouched Rats, which find landmines and memorise them in change of nice food (Poling et al. 2010). We reduce these analogue experiences in, call it, digital (countable) comparisons in terms of commonly agreed units (meters, Euros, grams, seconds). If we are able to give a recurring experimental finding a name, objectify it, and thence endow it with a measure, we reach an operational road to 'science.'[38] The next step is then to compare the experiences in terms of their features and properties, and start counting and modelling. But to make things even more difficult, we are

35. For an extensive discussion on the notion of time as being a reduction of change to a measure only, see:(Kircz, 2023)

36. As Rovelli is fond of references to old Greek and Roman pundits, I refer to Plato's Phaedrus (~ 280 CE, Plato 1973,) on the argument that writing (and consequentially also mathematical representations) is a dangerous reduction of human speech. In this context, the famous studies of Havelock (1963, 1983) on this issue are still relevant.

37. These are the instantiations of the reflection theory in F. Engels's sense one of Lenin's pillars in his (Lenin,1908 p.92 ff). Obviously the various representations in models, pictures, etc. of the external world are tools of the human mind in furthering our understanding.

38. Think in this regards also on the difference between use-value and exchange value in which we reduce (use) value to measurable (exchange) units for trade.

faced with questions such as the social evolutionary capacity of counting. The question is to what extent counting is innate in humans, e.g., as defended by (Lakoff & Núñez 2011), or, to what extent is it a product of social evolution: counting as a social activity? This phenomenon has been comprehensively reviewed by (Everett 2017), which looks at the limited 'art of counting' by tribes without trade as we know it. In the arts, we see combinations of colours and forms. When we look at a late painting of Piet Mondriaan (1872–1944), it can give a feeling of joy but also a temptation to count the number of squares compared to the number of rectangles. We can get the same type of feelings by looking at works of the op-art painter Victor Vasarely (Győző Vásárhelyi, 1906–1997).

Hence, one of the main occupations of modern physics (as a reduction of natural philosophy) is to drill deep into the subject matter to find objectified 'elementary' countable units. Only after we agree on such units can we start talking about the notion of amount, quantity, and possibly *quantity* **<–>** *quality* transitions, within a certain context (Kircz & van der Linden 2021). This assumes the fact that we master the art of counting (and subsequently arithmetic and algebra) as well as a notion of quality which allows us to segregate a collection of 'things' based on distinctive qualities with countable properties.

We can attack this problem from two sides. On the one hand, we start with a quality (or property, or Machian element; see below) and investigate a collection of 'objects' or 'things' with the same qualities, which in mathematical terms leads to technical terms like set, group, and ring theory. In this case, the common property of two objects can be defined by relations (called operations) such as addition that saves the chosen characteristics. Two or more objects can be added to reach a new object that fulfils the same characteristics. Ten one-ounce apples add up to a kilogram apples. A number plus a number gives a number, a vector plus a vector gives a vector. The importance of this (one can say in physics even hegemonic) mathematical approach allows for introducing many different operations. Addition is symmetric (so-called communicative: A+B =B+A), but in many cases, as with some kinds of multiplication, we don't have symmetry: AxB ≠BxA, which means the operation of A times object B is unequal to B times object A.[39] We see this when we multiplicate two bidimensional numerical objects called matrices (a kind of tables with rows and columns) which is generally not symmetric; that is to say: a times b is not equal to b times a. This so-called non- communicative behaviour (formally named non-Abelian), is the central concept

39. An easy example is rotation in three dimensions. Pick a book and turn it first along its length then along its width and finally along its depth. Change the order and you will not end up in the same situation.

of quantum mechanics. Relations and operations are the corner stone of Bogdanov's and now Rovelli's thinking.

One of the consequential riddles of counting and projecting numbers on a line (e.g. a ruler) is the notion of zero, a late invention in human culture. In calculations from bookkeeping to 'rocket science', we need the notion of the number zero. However, nothingness is still a subject of deep philosophical mediation.[40]

We encounter the same kind of problem with spatial understanding. How flat is the earth if we live on a globe? We experience flatness every moment. The Greek geometers saw this as a basic fact of life, and it became enshrined in Euclid's *Elements.* (Euclid of Alexandra ~300 BCE). Euclidean geometry systematises measurements and exhibits them as aspects of a formal structure, something more abstract and more exact than the appearances could express by themselves. So, a Euclidean (flat) space is a well-defined mental abstracted model, which allows modelling and theory development. Note that standard quantum mechanics 'lives' in–in principle infinite dimensional- Euclidean (so-called Hilbert) space.[41]

So, if we say 'here' we mean a point on a map, or better, in a cartographical representation with clear coordinates, we can name our position and can communicate this unambiguously to others.

The situation with 'now' is more complicated, as mentioned above, since we are unable to project the past, present, and future cartographically on a map. If we stay put, time still flows. It is my contention that the notion of time is a poor reduction of the more fundamental physical notion of change (Kircz 2023). In order to handle change, we rely on repetitive phenomena, which we consider stable (nowadays, the most stable 'norm is the atomic clock and its nuclear successor in development). In other words, time as we use the term is only a measure based on repetitive motion (which basics notion is named: harmonic oscillator). Time as notion is pertinent not a physical entity but a measure only. In the present paper, it is explicitly important that time as a parameter of change (a measure) is no way a physical entity and not an 'observable' in quantum mechanics. This sloppy way of using the notion of time only obscures a better understanding of the marvels of modern physics. [42]

7) Mach's Pragmatic Approach and the role of Socialism

In this section and following sections, I deal with the positivist and pragmatic analysis of science by the great Ernst Mach. His simplification,

40. A nice introduction to zero is (Kaplan 2000), see also an older good paper by the historian of mathematics (Boyer 1944).
41. For a more technical history of the notion of space (Max Jammer 1993), (Schemmel 2016).
42. For some entertaining books on time see: (Muller 2017) and (Callender 2010). For a deeper studies see: (Callender 2017), (Jammer 2006). For an extensive discussion on the notion of time as being a reduction of change to a measure only see (Kircz 2023).

grounded in the idea that only analogue sensory experiences are needed, was on the one hand a step forward, but on the other hand a reduction of all possible models and theories. It is in the Machian tradition that Heisenberg reduced the riddles of quantum mechanics to a formal mathematical system. Bogdanov was a critical follower of Mach.

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Ernst Mach was an atheistic humanist with strong social democratic leanings, one of the most versatile researchers of the second half of the 19th and the early beginning of the 20th century. He was, among many other things, a physicist with a great pallet of investigations, experimental as well as theoretical, ranging from ballistic shock waves, physiology, and sensory perception, to the history of physics. He was a prolific populariser and author. He inspired a whole generation of scientists. Mach was also a socialist who saw science as an emancipatory endeavour.[43] A prime socialist Machian was the physicist Friedrich Adler (1879–1960), (Adler 1908, 1910, 1916). Adler was a close friend of Albert Einstein (1879–1955), since they both worked in Zurich and lived in the same house (Fölsing 1997). Adler dropped out of physics (around 1910) and followed in the footsteps of this father Victor (1852–1918) by becoming a leader of the Austrian Social Democratic Workers Party (SDAP).[44]

Mach's studies in the historical and philosophical aspects of physics became fundamental for the development of the famous Vienna Circle and Logical empiricism (https://plato.stanford.edu/entries/vienna-circle/).[45]

The importance of this piece of history is that in the beginning of the 20th century, we see a strong international debate in socialist circles about the very merits of the debate, started by Marx & Engels themselves, about the place and role of the natural sciences in furthering socialist theory as well as their use of the term *Scientific Socialism* against

43. "Mach was appointed a life-long member of the upper chamber of the Austrian parliament upon retirement, although—in accordance with his views- he did not accept the title of nobility such an appointment usually entailed. Despite his poor health he had himself taken to parliament in an ambulance in 1901 to vote on the nine-hour working day—a process he repeated for the vote on the universal franchise in 1907" (Stadler, 2001, p.120).

44. Interestingly, in 1916 Friedrich Adler shot and killed the reactionary autocratic anti-Semitic Austrian premier Count Karl von Stűrgkh, whilst the later was having his habitual lunch in Hotel Meissl & Schadn. (Zimmermann 2015). After the war, Adler was released from prison and remained as active left social democrat a staunch supporter of Mach (Adler 1918).

45. The precise relationship between Mach's social(ist) thinking and the typical Austrian-Marxist current <https://rotbewegt.at/lexikon/austromarxismus/> is of continuing interest but falls outside the scope of this paper. However, it is of interest to note that many logical empiricists (aka logical positivists), and certainly not only the economist Otto Neurath (1882–1945) and the physicist Philipp Frank (1884–1966) were close to socialism, an emancipatory tradition that was scattered by the Stalinist policies and vicious attacks towards them from all sides. The downturn is well described by (Reisch 2005)

the pure voluntaristic utopians. In his critique (see below) Lenin is attacking not only Bogdanov on strategical political grounds, but also Mach and Adler. At present, Rovelli is resurrecting this debate, hence we discuss this complex.

Mach's lifelong investigation into the human perception of nature by the senses is the basis of his philosophy of science and his positivism. In the following the tensions between what we 'see' and what 'is' (outside our consciousness) is the red thread of our critique of certain interpretations of quantum mechanics and in particular Rovelli's relational quantum mechanics.[46]

8) Our Body and Its Reception of Nature according to the Mach School.

Our body is a vibrant concoction of various sensory capabilities. We feel, see, hear, etc., and each of these senses are in one way or another connected, and in varying combinations they give rise to bodily responses including thinking. All these sensory experiences are experiences of real activities in nature. In the Marxist tradition, these are reflected (but certainly not as an ideal mirror) [47] in the process of thinking.

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In order not to complicate matters, I refrain from dealing with the (in-his-time very popular) German-Swiss philosopher Richard Ludwig Heinrich Avenarius (born Richard Habermann) (1843–1896). He is known as the initiator of empiriocritisism and his idea of an energy-saving principle regulating knowledge, and his refusal of the distinction between a psychical inner world and a physical outer world (Russo Kraus 2020). He heavily influenced Mach and Bogdanov and hence became one of Lenin's main targets.

It goes without saying that as part of nature, our body and in particular our senses are in line, or better are tuned, with how nature 'behaves' in the given historical ecological situation we experience.[48]

46. Take the puzzling title of his book (Rovelli 2017) *Reality Is Not What It Seems*. This catchy title suggests that reality is some fixed "thing" out there, wearing different masks. Perhaps not reachable as Immanuel Kant (Kant 1998) poses, or an ever veiled reality as the French physicist d'Espagnat (1983, 2003) argues. In historical materialist terms, indeed nature (or reality) is infinite because in our human development we constantly add, activities, measurements, and hence world-views to our mental repertoire. I contend that 'reality' is a 'snap-shot' of an ever moving target, humans try to grasp. In other words: reality is exactly what we 'see' **now**. Ontologically, the only fixed reality invented by humans is God's plan.

47. Also here, a metaphor can play havoc with understanding. A spitting image means: to look very similar. But with a mirror image left and right are interchanged. It is a reflected duplication of an object that appears almost identical, but is reversed in the direction perpendicular to the mirror surface.

48. Despite all songs and poems, 'Mother nature' is not poetic at all. After all, when we are conceived as result of a—hopefully mutually enjoyed fusion—of an egg and a sperm cell,

Mach's emphasis on human sensory experiences as gate for understanding nature is the red thread in his works. Right from the first pages of his famous *The Analysis of Sensations* (Mach 1959, 6), we read:

> Thing, body, matter, are nothing apart from the combinations" of the elements,-the colors, sounds, and so forth -nothing apart from their so-called attributes. That protean pseudo-philosophical problem of the single thing with its many attributes, arises wholly from a misinterpretation of the fact, that summary comprehension and precise analysis, although both are provisionally justifiable and for many purposes profitable, cannot be carried on simultaneously. A body is one and unchangeable only so long as it is unnecessary to consider its details. Thus both: the earth and a billiard-ball are spheres, if we are willing to neglect all deviations from the spherical form, and if greater precision is not necessary. But when we are obliged to carry on investigations in orography or microscopy, both bodies cease to be spheres.[49]

And

> Bodies do not produce sensations, but complexes of elements (complexes of sensations) make up bodies. If, to the physicist, bodies appear the real, abiding existences, whilst the " elements " are regarded merely as their evanescent, transitory appearance, the physicist forgets, in the assumption cf such a view, that all bodies are but thought-symbols for complexes of elements (complexes of sensations). Here, too, the elements in question form the real, immediate, and ultimate foundation, which it is the task of physiologico-physical research to investigate." (Mach 1959, 13)

It would go too far in this paper to compare the idea that, e.g., colour is an ultimate element in relation to the Goethean colour theory (Goethe 2016) and Newton's experiments that show that *elementary* colours can be uniquely defined by a certain electromagnetic (the term was not known to Newton) frequency. (Sepper 1988), (Shapiro 1990).[50,51]

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we start as an integral part of the mother's body. Only after birth and the cut of our umbilical cord do we continue as a new natural semi-independent entity. It remains a (religious) mystery why some people think that nature was 'given' to us in order to mess things up.

49. For an analysis of Mach's use of the concept of pseudo-problem: "Like physical things, though, the ego is really of only relative permanence. Its apparent absolute permanence derives from its continuity, the slowness of its changes. But the egos of one person considered in their infancy and then in their mature years will share very few features. The ego, he [Mach] concludes, is as little absolutely permanent as are physical bodies. (Preston 2023)

50. Colour is one of the most fascinating sensory perceptions as, although frequencies can be assigned to what we humans perceive as colour, interestingly mixed colours like magenta or white don't have a unique frequency. Also various forms of "colour blindness" in humans induce great variations in the perception of coloured objects. The study of colorimetry is important in every aspect of human communications. To make things worse many animals have totally different colour perceptions than humans.

51. For a fundamental wide-ranging comprehensive work including the history of colour science see (OSA, 1953). After eight printings of this work, a second edition focusing 'on the

The intriguing point here is that Mach's phenomenology deals with active human (say analogue) perception whilst the 'scientific' approach since the 17th century deals more with abstract notions. Recently, the pressing question 'what I see as e.g., red, is indeed the same as the red as you see' was addressed by structural correspondence techniques and suggests that this method is a step forward away from the philosophical discussion on subjectivity to an empirical confirmation of likeness (Kawakita et al., 2025), which can serve as a materialistic arguments that humans are made of the same stuff and hence—on the average—experience the same stimuli the same. A related recent brain research study on colour about the relationship between subjective experiences and the brain underwrite this (Hirao, 2025).[52]

It is worthwhile to reread Mach's chapter IV, "The Formal Development of Mechanics," in his *The Science of Mechanics* (Mach 1960, 516 ff) to realise how "Nature is composed of sensations as its elements":

> Sensations are not signs of things; but on the contrary, a thing is a thought-symbol for a compound sensation of relative fixedness. Properly speaking the world is not composed of "things" as its elements, but of colors, tones, pressures, spaces, times in short what we ordinarily call individual sensations. The whole operation is a mere affair of economy. (Mach 1960, 516 ff)

What we see here in Mach's taking distance from metaphysics and religion is a scientific materialistic step forward to take the human body as source for human epistemology. It is still within a mind-body dualism because the very names of those elements, and the reduced—economical—construction of mathematical models, are results of human thinking as bodily activity within the given socio-historical context. In that sense, Lenin's and Popper's critique (see below) that Machism is 'idealistic' is correct. He did not make the next step, namely that human senses are those material affects of human experience and thoughts are the result of material activity. The more we learn about 'senses' beyond the traditional five (vision, hearing, smell, touch, taste), and now also e.g., balance and so-called interoceptions [any sense that is normally stimulated from within the body] are taken into account. The human body has more receptors that guide our actions than most people, and certainly in the 19th century, were aware of.[53]

The issue here is that until recently, only the five classical senses are taken into account as 'windows' to the outside world. Slowly, we learn that humans have more senses; consequently, we have to learn how to

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principles and observations that are foundations of modern colour science' was published (Shevell 2003).

52. A popular introduction this work is given by Hossenfelder's 'Scientists Measure Qualia for First Time' https://www.youtube.com/watch?v=NCD2A_bhDTI

53. https://en.wikipedia.org/wiki/Sense

address and use these senses, even if they are not so prominent, as other animals do.[54]

In his beautiful book, Yong (2022) dives deep in the sensory world of animals other than humans. This illustrates that, even if Mach is right that human knowledge of the complex of our limited senses is economically represented in sign language and particular mathematical models, it remains valid to claim from the materialist standpoint that there is a world outside humankind that can be explored and exploited by human mental labour. Even more, 'reduced' models sometimes suggest the existence of 'invisible' things such as atoms and molecules. Mach saw them as no more than mental tools, but during his lifetime, they were found with the help of our external extended senses—measuring tools and abstract theory.[55]

However, as a more-or-less independent species, human animals start their evolution with a kind of stimulus-respond phase, and after our brain (and ego) is ramped up we can consciously act. Philosophically, this poses the issue of how far an entity which is part of a whole can influence the whole. Certainly this must come from the inside (*pace* God), and hence it suggests that by experiment and theory building, we can grasp our situation and act in accordance with the natural environment (to save the species). We can also deliberately screw our environment up to the detriment of our species, forcing 'Mother Nature' to start-up evolution to a sentient being yet again.[56]

This means we deal with (at least) two major questions: a) what is our sensory perception, and b) if I percept, what is the relationship between me and the world around me?

It is the Mach school that pragmatically analyses the first question.

A crucial difference between Mach's approach to knowing the world and the above discussion on ignorance is e.g., Mach's pertinent division

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54. A beautiful example is that after the failed suggestion of Franz Mesmer (1734–1815) that large magnets could heal, it turned out that magnetism and 'Mesmerism' was more about group therapy than medicine, subsequently 'animal magnetism' was 'cancelled' for humans. Until it turned out that 'biomagnetism' plays a role in humans and we can e.g. measure magnetic fields in the heart.

55. This touches also the issue of the so-called anthropic (cosmological) principle discussion, which states that the fine-tuning features (laws, natural constants, etc.) of the universe can explain the conditions for the emergence of life. Obviously, if these features were different, carbon-based life as we know it might not exist. However, given that the situation is such that it exists and evolution is an expression of changing—ecological—situations, after the past five major extinctions on earth, humans are expressions of the possibilities given but not the only ones. The enigmatic octopuses prove that 'a different world is possible' within the present ecological situation. We care, not nature.

56. Given the idea that natural evolution is not goal oriented but seems to be simply striving to more and more complex structures, which give rise to thinking. In past discussions this was named a *vis viva*, but without further current knowledge this term is empty like God (or indeed metaphysical).

between 'non-living matter' (which, as a typical 19th c. scholar, F. Engels makes as well) and living, thinking matter.

> It is sometimes even asked whether inorganic "matter" has sensations. From our point of view the question is merely a perversion. Matter is for us not what is primarily given. What is primarily given is, rather, the elements, which, when standing to one another in a certain known relation, are called sensations. (Mach 1959, 243).

And

> "The behaviour of a crystal is already completely determined for our senses; and thus to ask whether a crystal has sensations, which would provide us with no further explanation of its behaviour, is a question without any practical or scientific meaning." (Mach 1959, 244).

Most recent research is questioning a sharp division between inorganic matter and living matter: bacteria, viruses, bacteriophages, viroids, etc. After all, many biologists discuss the idea that viruses are living, e.g.,

> I personally believe that the definition of life should be dramatically expanded to include viruses and viroids, but that's by no means a consensus view." "They're clearly biological replicators subject to evolution by natural selection and that's what matters for biologists." (Marshall 2025).

In this case, viroids and their ilk are at the base of things–they are more alive than rocks, but not as alive as bacteria or elephants.[57]

For Mach and his school, we don't speak about objects but of complexes of elements. This is a bit like talking only about the aspects and properties of a banana (as defined by human investigations) instead of talking about a banana. Elements are prior to objects for Mach. The difficulty is then that the further scientific investigations go, the more elements we have to add to the complex. Hence, when someday, as mentioned above, we accept that magnetism is a property of the human body as well, we enrich the notion of the human body as a given object, which is different than considering the complex of elements with a new member. Animal magnetism is now rechristened to bio-magnetism. We need a dynamic approach in which the growing sorts of objects of understanding are ever changing our theories of grasping nature.

A second key element of Mach's thinking is the notion of the economy of thought (for a recent study, see (Banks 2024)

Here, Mach defends that thinking strives to be as efficient as possible. Although Mach never really defined his economy of thought, it is close to pragmatics. In his *The Science of Mechanics,* he phrases it as follows.

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57 See also: Bruylants at al. 2010

> Science itself, therefore, may be regarded as consisting of the completest possible presentation of facts with the *least possible expenditure of thought.* (Mach 1960, 586)

and

> When I discovered that the idea of mental economy had been so frequently emphasised before and after my enunciation of it, my estimation of my personal achievement was necessarily lowered, but the idea itself appeared to me rather to gain in value on this account; and what appears to Husserl as a degradation of scientific thought, the association of it with vulgar or " blind" thinking, seemed to me to be precisely an exaltation of it. It has outgrown the scholar's study, being deeply rooted in the life of humanity and reacting powerfully upon it. (Mach 1960, 594)

Obviously, we can locate this idea of mental efficiency within the context of the capitalist economy. "...all our assertions have one and the same economical function, namely that of facilitating our mental reconstructions of facts" (Mach 1960, 606).

Think also of Mach's friend Willem James's statement that it is all about the cash value at the end of the day (James 1987, 573). But we can also see this as a metaphor for one of the many statements in physics, such as: light travels in a straight line in empty space or Fermat's principle which states that the path taken by a ray between two given points is the path that can be travelled in the least time, or a body follows a locally shortest path between two given points in a curved space.[58] The upshot is that the most 'economic' description of physical process comes closest to a 'real' natural law.

9) Is Thinking an Element?

Now we will discuss the issue to what extent a (physical) fact can be named and how naming and experience develop in tandem. This is closely related to the concept that we have fixed objects with fixed names. As already discussed above, the dynamical interplay between naming and object is at stake. The bottom line after all is that we link pure formal (sign) languages and their pure formal relations to the task of 'squaring the circle'; back to Archimedes.

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Evald Vasilievich Ilyenkov, who was strongly inspired by Baruch Spinoza's (1632–1677) statement that legs and walking are intertwined

58. Here the least economy is illustrated by the fact that an aeroplane from Amsterdam flows as north as possible to Japan, instead of following a circle (parallel or latitude); we speak of the principle of least action, in which action is a scalar quantity that describes how the balance of kinetic versus potential energy of a physical system changes with trajectory. https://en.wikipedia.org/wiki/Action_(physics)

(Ilyenkov 2014), introduces the notion that thinking and formulating an Ideal is a material (bodily) phenomena (see section 5 above).[59]

In his polemic against Mach, Lenin wrote:

> Sensation depends on the brain, nerves, retina, etc., i.e., on matter organised in a definite way. The existence of matter does not depend on sensation. Matter is primary. Sensation, thought, and consciousness are the supreme products of matter organised in a particular way. Such are the views of materialism in general, and of Marx and Engels in particular. (Lenin 1908, 55)

However, in his polemic in defence of philosophical materialism, he does not reach the level of Ilyenkov in investigating whether socially accepted notions have a material value.

Now obviously, Lenin in 1908 still refers to matter in a more or less 19th-century context, but here we talk about mental expressions (we call it colour, we call it solid, we call it pain) which vocal expressions are grounded in the part of the body called the brain. And Lenin is pretty pragmatic about the flexible meaning of words. He quotes Engels:

> But just as idealism underwent a series of stages of development, so also did materialism. With each epoch-making discovery even in the sphere of natural science [Lenin adds: "not to speak of the history of mankind"] it has to change its form; and history too having been subjected to materialistic treatment, a new avenue of development has opened here as well. (Engels 1886, 369)

In the discussion of transmutation of chemical elements and the discovery of radium as a new kind of matter, (Lenin 1908, 250–313) Lenin is clear: materialism is not about the matter in its 18th c notion but what exists in 'nature' without God or humans. Hence, the form of materialism changes and e.g., radiation is solidly part of the material environment. After 1905, we even now accept the identity between mass and energy. So, we are dealing with the ever-changing problem of experiencing parts of nature (sometimes indirectly as we see the display of a voltmeter as representation of what we defined as an electric potential difference -in the unit Volts) and then fixing it with a well-defined name and measure. An outstanding research issue is how e.g., a rise in blood pressure and acoustic screams due to an electric shock is communicated in ever changing (scientific) language.

These sensory processes are not one-way traffic, as our sensory 'measurements' leads not only to bodily mechanical actions (immediately withdrawing your hand from fire), but also to analytical thinking

59. It is interesting, but outside the scope of this paper to analyse Ilyenkov's discussion on psychology in which he stipulates a sharp cut with the act of birth after which the new human develops its consciousness as a pure social product of life (Ilyenkov 2010).

in trying to understand what is going on and why, with the goal to master and exploit the sensory data in mastering our environment. All our bodily actions have a 'reaction' towards our environment, or better, a continuous interaction, where it is still unclear what the 'primordial' action is and what the reaction, which in itself is an action again.[60]

Repetitive sensory experiences induce what we call the process of inductive theory-building and philosophical empiricism. Empiricism needs guiding rails, fundamental basic notions, to develop. The old philosophical question is to what extent empirical 'data' are sufficient to reach a descriptive theory in which these data play a natural constructive role. A hunch or, better, a theory, is needed to guide the experimental findings into an understanding,

A pertinent question is to what extent my sensory experience, seen as an element which I connect with a concept (heavy, large, strong ...), is stable and the same for all subjects of species. In Mach's approach, the complex of experienced elements will become larger the further we advance in science. The problem now is that if we start—heuristically—with a material object with a name, we will always find more attributes. For instance, in the case of uranium decay, we experience ejections from a uranium particle, of so-called alpha and beta particles. The first is a helium nucleus (2 protons and 2 neutrons), the second an electron. So, by watching uranium radioactivity, we expand our sensory complex with 2 new entities. But the original complex uranium (of the most common isotope 238)[61] is now the complex of Thorium 234, an alpha particle and an electron, and so further down.

If we just start by counting particles, we reach the same sensory results, but now our understanding is much simpler. In more complicated (e.g., macroscopic) situations a particle view is far easier than a complex of sensory experiences. Mach is right that our knowledge comes from sensory perception, but a (more or less) stable object is more fundamental than individual human—bodily—perceptions. Mach's problem with the concept of an atom came forth because he could not accept that an atom was more than a mental operational tool, but was not (yet) proven physical. In the same vein Mach treating mathematical notions. Dimensions for him are the three special dimensions we experience. This is

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60. Only in brute macroscopic stimulus-response situations, as we know since the 1897 experiments of the physiologist Ivan Petrovitsj Pavlov (1849–1936), the "Pavlovian conditioning" tells us that a stimulus, such as food in case of a hungry dog induces a neutral effect (salivation). Obviously salivation does not induce the reflex of food delivery. Nevertheless, the single-directional stimulus-reopens research became a pillar of "Behaviour Science," including its mathematical modelling. The question of bi-directionality is a theme in Marxist studies.

61. Elements from the periodic system have a name and an atomic number, which is the number of positive protons. On top of that the nucleus has a varying number of neutral neutron elementally particle. ^{238}U has element number 92, so 92 protons and 146 neutrons. The nucleus has an electron cloud of 92 electrons.

also an argument against Kant's fixed *Ding an sich*. This reasoning comes back with Rovelli's strong antipathy for so-called Hidden Variables, in his quantum mechanics.

10) Towards the Twentieth Century

Mach, Engels, Lenin, and Bogdanov are children of the 19th century, where the idea got hold that physics is more or less complete. Indeed, it worked. But in the first decades of the 20th century, this contention was completely scattered. Rock-solid ideas had to be abandoned with the breakthrough of fundamental granularity (quantum mechanics) on the one hand and the theory of gravity (general relativity) on the other hand. And now, one century later, we have no clue how to merge them into an overall understanding.

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As said above, in human history, we know two fundamental notions, which in all theoretical and practical human activity we take as a given: time and place; now and here. The third pillar: causality, we leave until we discuss quantum mechanics. Leaning heavily on Newtonian mechanics, Kant starts his investigations with the postulation of *a priori*.

> But although all our cognition commences **with** experience, yet it does not on that account all arise **from** experience. For it could well be that even our experimental cognition is a composite of that which we receive through impressions and that which our own cognitive faculty (merely prompted by sensible impressions) provides out of itself, which addition we cannot distinguish from that fundamental material until long practice has made us attentive to it and skilled in separating it out.
> It is therefore at least a question requiring closer investigation, and one not to be dismissed at first glance, whether there is any such cognition independent of all experience and even of all impressions of the senses. One calls such **cognitions a priori**, and distinguishes them from **empirical** ones, which have their sources *a posteriori*, namely in experience. (Kant 1998, 136, B2)

Hence, in an almost pragmatic move, we decree here that space and time are so fundamental that we cannot go around these notions. And here and now the problem starts: how do we develop these basic (one can say analogue) notions {a photo of Werner} into well-defined notions {Werner on an afternoon beach at Helgoland} or more "data-driven" {Werner @3 pm @ 54°11'19.49"N, 7°53'2.34"E, elevation 1m} which allow operational approaches that enable us for communications between humans, independent from their vernacular, actual space and time algorithms, towards forecasting. The open question is whether these human notions are sufficient and complete to describe and understand nature. After all, many non-human animals have totally different senses, and we have no idea if and how they experience and interpret nature. The standard reasoning is that because humans can think and abstract their sensory experiences into theoretical models, together with the proposition that humans are at the top of evolution, the Kantian *a priori* must be fundamental stepping stones.

The other approach is the drive for more specific language per situation as an answer to the reductionist drive to mathematisation and the perceived universal value of 'physical laws.' This searching for incommensurable descriptions is also the characteristics of fashions or currents in the arts and in music. Richard Wagner is difficult to "map" onto the schemas of J.S. Bach, and Karel Apel or Jackson Pollack don't fit Rembrandt van Rijn, or the mature works of Piet Mondriaan. In biology we see the 'disorder' school against unification and stratification as advanced in physics and chemistry (Dupré 1993).

The materialist question, Marxist style, is something which goes beyond the various schemas and reductionist hopes of an ultimate grounding (including atomistic creation, such as that defended in religions or other suggestions of a unique, once-in-a-lifetime, 'big bang'). Obviously, in analysing 'here and now' against the changing 'fluidity' of nature, we have to deal with the successes and failures of all serious investigations as far as we are aware of (Kircz 2022).

The most important lesson we have to keep in mind is that the human species, in evolutionary terms, is pretty young, and as our thinking is developed in tune with our societal development (give and take a possible genetic development due to epigenetic influences), we have no reason to think that we can reach an overall knowledge of the world nor an overall philosophical system. As argued previously, the only pertinent statement we can make is that the larger, or more encompassing, our knowledge becomes, the larger our ignorance.

11) Stay Tuned

The previous sections tried to be a kind of *mise en place*. In the following, I will drill down to the nuts and bolts of the battles between Lenin and Bogdanov, to reach a semi-finished inspection of the relational quantum mechanics of Carlo Rovelli.

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To close my already lengthy introduction, we will now discuss the Lenin-Bogdanov controversy to get a grip on the claim that Bogdanov's empiriomonism, which is an attempt to fuse positivism with Marxism.

However, before we can go on, I must make three fundamental comments.

1) As said above, there are more sensory perceptions than during Mach's lifetime that are considered as a given. But even given that, our traditional sensory organs are not fully appreciated. For example, it is now understood that the human eye can see a single light particle (photon) (Tinsley et al. 2016). We also can argue that elementary chemical processes in the body are operating on the quantum level. This dovetails

with Rovelli's conviction (see below) that we have to take macroscopic and microscopic situations as a whole and not as separate things. The fact that most of the time we don't measure (see) quantum effects in macroscopic objects is most presumably the effect of mixing and so-called decoherence (loss of information of a system to its environment). This is a cornerstone of Niels Bohr's demand for 'correspondence' between the macroscopic measuring device (e.g., a voltmeter) and the quantum state of the measured object.

2) Closely related to the above, in Marxist terms, we have to understand that different situations are ruled by different rules.

This is the issue of the dialectics of quantity ↔ quality transitions. Not the most simple of the often so-called dialectical laws, because in the 19th-century discussions it was mainly illustrated by macroscopic objects. At present, we have to consider that although properties can and will emerge from these kinds of transitions, they can also exist in parallel in function of what we investigate (Kircz and van der Linden 2021).

3) In the pragmatic worldview, we try to reduce the number of properties of an object or a process to some fundamental entities, or in the same vein, use a coordinate system on which properties can be projected and hence compared, e.g., extension with the use of a ruler with centimetre indicators. Indeed, an economy of thinking. We quickly enter the world of information, in its formal guise, a numerical value about a property, and in the digital world, a bi-valued yes/no (on/off) 'bit' (binary digit). This reduction, which fits formal logical-based calculations, creates problems if we deal with more complex situations. I will discuss this below in the section on Rovelli's quantum mechanics. It is well accepted that the Second law of thermodynamics (heat flows from warm to cold and not the other way) suggests that there is a tendency, we witness, of an increase of disorder; so-called entropy increase. However, if we take, as argued in this paper, that it is explicitly the yet unknown that is growing in human investigations, we might say that in this case, despite the drive to drill down to simple final theories, we encounter a growth of (mental) entropy. It would go beyond this paper to ponder this issue of, on the one hand, reduction to digital information versus the counter movement of the emergence of even novel unknowns.

12) The Bogdanov—Lenin Controversy

The battle between positivism and historical materialism will now be discussed based on the two protagonists, Bogdanov and Lenin. The importance is not only the epistemological aspect, nor the colliding egos, but the appreciation of what social reality is and its political consequences. This in line with the idea of a scientific approach towards human emancipation from religion, misery, and exploitation.

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The main issue, as explained above, is the question of the level of knowability of nature in the context of the social-economical-political situation and the application of this knowledge, which serves as a boundary condition as well as a guiding rails for socialist action. In philosophical terms this boils down to the quest for the meaning of 'reality' as well as the ever changing emancipation of humankind from its bodily limits and mental obscurantisms. For that reason, the lesson of historical materialism is to reflect on the ever-changing analysis and notions in the socialist tradition and adjust and expand where needed. This is not only a natural sciences issue.[62] Societal structures claim that what they express is 'normal' and 'the reality.' Think about the reality of the fact that IQ measurements prove the reality that white male are superior, or that women's natural (almost Aristotelian) place is in the kitchen, etc., etc. We have to understand that in the debate between Lenin and Bogdanov it is not about lofty philosophy or a personal power struggle in the Bolshevik party, but also a social analysis of the then-actual Russian political situation and the tasks and actions of the organised labour movement to overturn Czarism: the reality of the class composition in backward Russia and route to emancipation by taking state power, to try and show that another world is possible. Which means: what is our view about nature beyond our direct confrontations?

12A) What did Bogdanov say?

Bogdanov was three years younger than Lenin and six years older than Trotsky, hence all three political heroes are products of the same social-political Russian environment. According to Bogdanov's autobiography (Bogdanov 2020 p-xii), he started young as a political activist and in the autumn of 1903, he took the side of the Bolsheviks, met with Lenin in 1904, and joined the 'Bureau of Committees of the Majority (BKB), the first Bolshevik Centre.' He wrote an acclaimed introduction to Marxist economy (Bogdanov 1923) and developed his ideas in the three books on Empiriomonism (in 1904, 1905, and 1908, respectively), translated and collected in (Bogdanov 2020). After Lenin's (1908) attack on Empiriocriticism, Bogdanov published *The Philosophy of Living Experience* (Bogdanov 2016), which can be considered his final philosophical writing and is partly a rebuttal of (Lenin 1908). For our discussion, I will try to compress the arguments, as both authors are aggressive and verbose polemicists (which was 'the normal' in those days), and I don't refer to many contemporary (and now mostly forgotten) players in the political-philosophical arena whose works are only partly available for the present author. It has to be said that, given the harsh political environment of

62. The prime examples for dynamic adjustments in socialist thinking are obviously feminism and ecology, whilst these issues were addressed by the founding fathers and their political offspring, at present these issues are in full development.

those days and subsequently the Stalinist sanctification of Lenin, Bogdanov's approach to materialism was 'cancelled,' which, by the way, is no reason to canonise him nowadays in turn.

Important lines of reasoning are Bogdanov's unification in a monist way towards human experiences and human thinking and his search for equilibrium. This, in terms of the then-popular theory of energetics, is where energy is a fundamentally conserved entity. A conserved entity is an important notion established by Hermann Ludwig Ferdinand von Helmholtz (1821–1894) to which Engels, in a dialectical way, subscribed as well. It means that taken in its totality we can talk about a constant value, though within this totality the distribution can change; e.g. the energy of motion can change to thermal energy. For Bogdanov it is a fluid continuum; for Engels it can be seen as an example of a unity of opposites (see also Kircz 2022).

In my view, Bogdanov only follows Marx & Engels in their fundamental historical materialist methodology.[63] He bifurcates from them on the level of dialectics which, after all, contradicts a final equilibrium; Bogdanov is looking for equilibrium in his emancipatory thinking.[64]

I contend that historical materialism is the source for the new thinking of dialectical materialism, whilst in the Stalinist infamous *short course* school the eternal laws of Diamat contain historical materialism as an application of these perceived laws.[65] Which in my opinion is pure metaphysics: laws are human-made.

As few people are conversant with Bogdanov's philosophical phenomenological works but might know more of Lenin's harsh attack, I start with an avalanche of quotation to clarify the issues at stake.[66]

> Empiriocriticism is a contemporary form of positivism that has developed on the basis of the modern methods of natural science, on the one hand, and of modern forms of philosophical criticism, on the other. This philosophical current found its most prominent exponents in Ernst Mach and Richard Avenarius, the first of whom formulated it with particular clarity and lucidity,

63. As Lenin in his positive critical review of Bogdanov's *Short course of economic science* writes: "The outstanding merit of Mr. Bogdanov's Course is that the author adheres consistently to historical materialism" (Lenin 1898, LCW vol. 4 p.48).

64. An interesting paper by the economic historian Andrei A. Belykh (Belykh 1990) makes a comparison between Bogdanov and the economic equilibrium theory of Nikolai Ivanovich Bukharin (1888–1938).

65. https://www.marxists.org/reference/archive/stalin/works/1939/x01/index.htm

66. Bogdanov translator David Rowley recently published a useful kind of overview of Bogdanov's development solely based on quotations and with a very limited amount of counterarguments from others (Rowley 2024). Strange enough he doesn't mirror Bogdanov's elementary works in economy with the intense discussions in Marxists circles (e.g. Bukharin) and only names the 1949 anti-Marxist work of Böhm-Bawerk. Also the title "Marxism as a naturel science" is most ambiguous as it suggests that Bogdanov's philosophy of science (his mechanistic tektology) can be seen as a scientific standard.

> and the second of whom formulated it with particular completeness and precision. (Bogdanov 2020, 5).

Although following Mach in its emphasis on sensory experience, Bogdanov goes further and stipulates:

> It is precisely this uniformity of relationships, observed for the various series of experience [physical and mental–JK], that is the immediate basis for the unity of a body. The spatial and temporal unity of a body is only a particular form of that uniformity of relationships, of that parallelism of the various series. Visual space, for example, is coordinated with tactile space precisely by virtue of the parallelism between the different series of elements, and the unity of time is really another name for the parallel flow of all these series amid the general stream of immediate experiences. Let us note that one of these series usually plays a special organising role in a complex.
>
> ...But what kind of difference is there between a 'body' and the 'perception' of a body or the 'psychical image' of it? After all, these are unquestionably far from being the same thing as far as our experience is concerned (Bogdanov 2020 11).

We see here already two essential aspects of Bogdanov's thinking: the unity of the various sensory and psychological experiences and the role of organisation. He follows up with extensive discussions on the psychical realm:

> Besides those complexes that can appear equally in the physical series (as bodies) and also in the psychical series (as perceptions or psychical images), complexes of another kind nevertheless also exist that pertain entirely to the psychical world and that we never attribute to the physical realm of experience…
>
> The specifically-psychical character of this entire group of experiences is determined by the fact that it is particularly and immediately dependent on the state of a given nervous system and cannot be conceived of outside of that dependence—outside of the regular interconnectedness that characterises the physical sphere of experience (Bogdanov 2020, 13).

He also anticipates allegations of Idealism:

> …it is far from immanent idealism because it absolutely does not locate reality and experience entirely within the confines of the psyche and of 'psychical images.' Instead, it treats the 'psychical' as only one specific realm of experience. Empiriocriticism has nothing to do with either materialism or spiritualism or with any kind of metaphysics in general; for Empiriocriticism, both matter and spirit are only complexes of elements, and any 'essence' or supra-experiential knowledge are terms without content, empty abstractions. To characterise emperiocriticism as critical, evolutionary, and sociologically-coloured positivism would be to immediately indicate the main currents of philosophical thought which flow into it. By breaking down all

> that is physical and all that is psychical into identical elements, emperiocritisism does not permit the possibility of any kind of dualism. (Bogdanov 2020, 14).

Bogdanov argues that:

> The invariable element of all characterisations of anything that is 'physical' is the latter's objectivity. No one can conceive of a physical body or process which could be designated as something 'subjective.' There are no exceptions whatever. But what does 'objective' mean? (Bogdanov 2020 16).
>
> We arrive at the following conclusion: the characterisation of 'objectivity' altogether cannot be based on individual experience–neither the stability of its compositions nor the harmony between the results of activity and the data of experience that is the starting point of that activity. The basis of 'objectivity' must lie in the sphere of collective experience (Bogdanov 2020, 18).

Obviously, every serious notion lies in the sphere of collective experience, and this argument also holds for religious and idealistic currents, often with century-long collective experiences. However, it is the changing content of an objective fact that must be taken into account.

> In the theory of space it is necessary to strictly distinguish between the space of sensory perception and abstract space ... or between physiological and geometrical space in Mach's terms. Although the two kinds of space are inseparably connected, they nevertheless play different roles in the system of experience. Physiological space is what our immediate experience gives us in the act of seeing or the act of touching. It is what we directly perceive in the form of the optical and tactile series of elements. Abstract space is the space of our thought. It is all-embracing and is not connected with any particular perception; it is space that is presented to us as a 'universal' or 'pure' form of contemplation. The characteristics of these two kinds of space are very different in many ways. Physiological space possesses neither uniformity, nor continuity, nor permanency of relationships, or, to be more exact, it possesses all these things but only in part. Things appear to be different in different parts of physiological space (Bogdanov 2020, 19).

This is exactly the reason why I started this study with the demand for clear definitions and the role of language. Bogdanov uses the word 'space' in a very loose way, as a container of something not necessarily endowed with measures. But as soon as we want to make matters operational in order to forward human experience and knowledge, we need measures, dimensions, and coordinates. By conflating concepts from different fields of human experience, we disable clearness of meaning and remain on the level of metaphors. I wonder how a good medical doctor (and Bogdanov was one) deals with the not 'permanency of relationship' of say, the usages of Aspirin for headaches.

We can certainly not blame Bogdanov for his Kantian belief that:

> "Abstract space is *free of contradictions*. Abstract space is strictly regular and is completely uniform everywhere…"

until we socially accepted that curved space is not uniform, given the distribution of masses, which only became clear in the 1920s. After addressing the historicity of the Newtonian/ Kantian notion of absolute space. Bogdanov correctly stipulates:

> This leads us to the following important proposition: the objectivity, or social validity, of given forms of space and time applies in reality only to beings that are significantly close in the level of their cognitive development (Bogdanov 2020, 22).
>
> So, in the end, what do abstract forms of space and time in fact signify? They express the social organisation of experience (Bogdanov 2020, 24).
>
> In general, the physical world is socially-coordinated, socially-harmonised, in a word, socially-organised experience. This is why we find abstract space and time–these fundamental forms in which the social organisation of experience is expressed–to be inseparable from the physical world (Bogdanov 2020, 25).

Kant would say *a priori*: Indeed, scientific knowledge is a social-historical voyage. However, we are now confronted with the miracle that the descriptive quantum mechanics works, but nobody knows why? To quote the great teacher and Nobel laureate Richard Feynman: "nobody understands quantum mechanics."[67] We only have interpretations and pragmatic calculations of the level of the well-known phrase 'shut-up and calculate.' As its author David Mermin coined it:

> Most of us, in fact feel irritated, bored and downright uncomfortable when asked to articulate what we *really* think about quantum mechanics. I'm one of the uncomfortable ones. If I were forced to sum up in one sentence what the Copenhagen interpretation says to me, it would be "Shut up and calculate." But I won't shut up. I would rather celebrate the strangeness of quantum theory than deny it, because I believe it still has interesting things to teach us about how certain powerful but flawed verbal and mental tools we once took for granted continue to infect our thinking in subtly hidden ways… (Mermin 1989)

The central issue in Bogdanov's contention that although all knowledge is socialised, knowledge is in a certain sense individual. In other words, a solipsistic sociology of knowledge.

> The realm of the psyche is characterised first and foremost by the fact that the psychical experiences of one individual do not possess social validity in relation to other people. My perceptions and psychical images, taken in their immediacy, exist only for me, and they acquire cognitive significance for

67. https://youtu.be/w3ZRLllWgHI

> other people only indirectly, and, moreover, only in part. The very same thing applies to my emotions and desires (Bogdanov 2020, 27).

This is a strong statement, as many perceptions (is my red yours? see above) are results of bodily activities as well as cultural traditions, e.g., Vampires. Certainly, individual humans have individual emotions, but the lessons of psycho-somatic conditions could not be made if we deal only with pure individual situations.

Bogdanov clarifies this with the following:

> For an astronomer who has just discovered a comet, the comet still remains only an individual complex of elements of experience. But inasmuch as the astronomer immediately places it in the domain of socially-organised experience, situates it in the common interconnectedness of this experience, and coordinates it with other data, then his individual experience immediately becomes a constituent part of socially-organised experience—in this case, the world of astronomy (Bogdanov 2020, 28).

But he forgets the very fact that the individual astronomer can only discover a 'comet' if she is trained in the socialised experience of identifying and defining comets. However, the comet doesn't know its name but simply exists as a material object in the sky.

A central issue for Bogdanov is harmonious organisation with a hierarchical characteristic:

> Laws do not belong to the sphere of experience–to the sphere of immediate experiences–at all. Laws are the result of the cognitive processing of experience. Laws are not given in experience, but are created by thought as a means of organising experience, of harmoniously coordinating it into a coherent whole. Laws are cognitive abstractions, and physical laws are just as lacking in physical properties as psychological laws are lacking in psychical properties (Bogdanov 2020, 28)

In his critique, Lenin counters this strong statement bluntly with:

> And so, the law that winter succeeds autumn and the spring winter is not given us in experience but is created by thought as a means of organising, harmonising, co-ordinating ... what with what, Comrade Bogdanov? (Lenin 1908, 168).

Indeed, this calls for clarity if we deal with experimental regularities in nature or with human-invented descriptive lawful tools such as the excluded middle?

And:

> There can be no doubt that a lower unity can be an integral part of a higher unity, so long as it is sufficiently coordinated with the other lower unities that compose the higher one (Bogdanov 2020, 33).

Here we come to the issue of whether we only have to do with 'higher' unities, say from atomic chemical elements to molecules and subsequently crystals, or also with aggregated individual units, e.g., a coral reef? In dialectical terms, we enter here the fascinating field of quantity ↔ quality transitions which in systems theories certainly also demands further investigations (Kircz and van der Linden 2021).

Against Mach and Avenarius (1843–1896), Bogdanov challenges the idea of two series of experiencing, the physical and the psychical, and fused them in his monistic approach.

> Those 'questions of dualism' that we would have to pose to empiriocritical monism no longer present any particular difficulties for us. While we find two fundamentally different regularities in a single stream of human experience, nevertheless both of them have their source in our own organisation. They express two biologically-organising tendencies by virtue of which we enter into experience simultaneously as individuals and as elements of a social whole. To the question of why there are only two of these types of organisation of experience, we say that the answer is to be sought in the biological and social history of humanity. History relates how the tribal life of humanity arose in the struggle for survival, how the individual person was separated out of humanity and, at the same time, an ever broader social interconnectedness unfolded, and, finally, how human forms of thinking, with their real duality, developed and adapted to that very struggle for survival. In so doing, the question is answered of why some complexes of elements of experience are present sometimes in the physical series and sometimes in the psychical series, while others are present only in the psychical series. Emotional and volitional complexes are exclusively psychical, i.e. they are those experiences that, according to the conditions of the social and intra-social struggle, are most differently directed in different people (Bogdanov 2020, 29).

So, Bogdanov claims to take the historicity of our social life from Marx, but add the psycho-emotional as bodily (hence material) as part of a monist complex. But emotions and volitions seem here to be taken as trans-historical phenomena and not based in the social-historical environment in which they express themselves.

Within this whole there is a striving toward harmony.[68]

> In a great number of cases one can observe the mutual correspondence and harmony of both series of experience—the physical and the psychical—and

68. It is important to note that at the time of writing the, now defunct, theory of Energetics with Ostwald and Mach as strong protagonist was very popular. This theory takes energy as fundamental ultimate element, contra atomism (Ostwald 1895). Wilhelm Friedrich Ostwald (1853–1932), was one of the founders of chemical physics (Nobel prize 1909 on chemical equilibria). At that time we saw vigorous debates against the notion of atoms as fundamental units. Only after the successes of Ludwig Eduard Boltzmann's (1844–1906) statistical mechanics and the acceptance of the existence of atoms and molecules after 1905, energetics was phased out. Also the 'fluidity' of matter striving to thermodynamic equilibrium is clearly an ingredient in energetics.

> in a great number of cases one can observe the mutual contention and even contradiction of the two series. Harmony and correspondence are revealed in the most immediate form in cases where perceptions and psychical images can be said to be 'true' or to 'correspond to the things themselves' such that a physical body and the psychical image of that body 'coincide' sufficiently enough so that practical and theoretical misunderstandings do not result. Conversely, when perceptions and psychical images are 'wrong' or 'do not correspond to things,' there is mutual lack of correspondence and disharmony between socially-organised and individually-organised experience (the physical and the psychical series) (Bogdanov 2020, 30).

And,

> Here harmony boils down to the fact that both the physical and the psychical are placed under the very same generalising forms–'categories' or 'laws'–and a contradiction arises where this is not successful. For example, to the extent that cognising people subordinates both the physical and the psychical to a single law of causality, both series are harmoniously united in cognition, but to the extent that the cognising people place the physical under the category of causality and the psychical under the category of 'freedom' (i.e. a state that is not conditional on something else) or to the extent that they represent the causal chain of both series as absolutely separate and not merging at any point, what results is a contradiction between the physical and the psychical series in the form of 'dualism'–i.e. it is impossible for cognition to complete its unifying and generalising tendency (Bogdanov 2020, 30).

Bogdanov concludes this line of thinking with:

> Precisely this sort of actively-organising activity of cognition can, in our opinion, remove dualist contradictions and lead to a really harmonious world view. This will not be a monism of 'essence' or of 'reality.' Empty concepts such as these cannot satisfy critically-monist thinking. It will be a monism of a type of organisation that will systematise experience, a monism of cognitional method. Let us see what, in reality, this method provides the cognising person in the pursuit of a unified worldview (Bogdanov 2020, 38)

We see here a step in the direction of tektology, Bogdanov's precursor of operational research.

> In reality, cognition does not need to create a special method for each of the parallel series that flow together in one or another complex; cognition deals with whole complexes. The psychophysiological process, cognised as one whole, must fit within the confines of the same method by which the physiological process is cognised from its several series. This is the method of physical science for our times–the method of energetics. And, by the way, it makes absolutely no difference whether we take elements from the 'physiological' series or from the 'psychical' series to analyse.
>
> A common world of experience will emerge as content for a common cognition. This is empiriomonism. Empiriomonism is possible only because cognition actively harmonises experience, removing its innumerable contradictions, creating universal organising forms for experience, and replacing the

> primary, chaotic world of elements with the derivative, orderly world of relationships (Bogdanov 2020, 39).

Bogdanov's political romanticism (in sharp contrast with Lenin) is expressed in the statement:

> Harmoniously organised collective experience would give people the kind of grandiose fullness of life that we people of an era of contradictions can not conceive. In such a world as this, it would also be easy for cognition to unite the whole sum of human experiences in harmoniously-whole, infinitely-plastic forms, in which the experience of each person flows organically together with the experience of everyone else (Bogdanov 2020, 43).

This is concretised in his sci-fi novel (Bogdanov 1984).

In chapter 2: 'Life and the Psyche,' Bogdanov dwells on an extended discussion on the then-current discussions in and knowledge of psychology. He typically addresses the issue of what we now name 'psycho-somatic' conditions, as he concludes that:

> More precise and more direct correspondences are necessary in order to resolve the issue of psychophysical parallelism (Bogdanov 2020, 47).

And:

> We have arrived here at what is essentially a tautological proposition. As modern positive philosophy has established, the elements of psychical experience are identical with the elements of all experience in general, and therefore they are also identical with elements of physical experience. Elements of experience (chromatic, innervative, tactile, acoustic, etc.)–elements of red and green, elements of extension, elements of hard and soft, warm and cold, elementary tones, etc.–all equally form both the 'bodies' of the objective, physical world and the perceptions, forms, and psychical images of the psychical world. The difference is only in the type of grouping–in the nature of the interconnectedness which appears in one case as the interconnectedness of objective regularity and in the other case as the interconnectedness of associations…
>
> It is necessary only to add that the type of grouping of elements in both experiences is also identical–that is to say, it is associative–as we can confidently conclude from the utterances that correspond to both psychical and physical experience (Bogdanov 2020, 63).
>
> The material of life and all of nature is the same everywhere; it is the groupings of that material that are different. The development of life always signifies the same thing: the growth of organisation in the grouping of elements (Bogdanov 2020, 64).

Although the elements seems to be 'atomic' and can be grouped, which is in contradistinction with Ostwald's, energetics comes back a few pages later.[69]

> At the basis of the phenomena of life lies a fluid equilibrium of energy, a two-way flow between a living system and its environment. Assimilation, the intake of energy from the external environment goes side by side with disassimilation, the expenditure of energy, its dissipation in that same environment. A complete equilibrium of both flows in all parts of the system would be a case of ideal conservation (Bogdanov 2020, 68).

The atomicity of energy was only suggested in 1900 by Max Karl Ernst Ludwig Planck (1858–1947), who we discuss below, and taken as given by Albert Einstein's (1879–1955) photoelectric effect theory in 1905. Taking energy as a fluid is not strange, as mentioned above; in the macroscopic world, heat is also taken as a fluid.

Against Avenarius, Bogdanov argues in the context of the fundamental notion of the conservation of energy that:

> First and foremost, we must remove the crudely materialistic and imprecise term 'nourishment' ('*Ernährung*') [seen as a kind of potential energy, JK] from our analysis. The process of nourishment is only the main path of assimilation of external energy into the system, but it is not the only path. There is every reason to believe that energy—for example, the minor stimuli that reach the central system along neural conductors—can be assimilated by neural cells, elevating their store of potential energy. The term 'nourishment' needlessly muddies the waters, forcing us to always conceive of the process of vital assimilation as the intake of material particles, when the reality is a flow of energy for which such particles are only one of the usual forms (Bogdanov 2020, 67).

In chapter 3, 'The Monist conception of life,' Bogdanov deals more with the issue of psychoenergetics.

> To accept psychoenergetics in principle it is sufficient only to acknowledge a constant connection between physiological processes and experiences—any connection as long as it is completely specific and has one meaning for each given case (Bogdanov 2020, 88).

Again, we see an attempt to merge the notion of fluidity with real-world countable 'things' like neurons. A more philosophical fundamental remark is that:

> However, have we not arrived at the philosophical doctrine that says that the physical and the psychical are 'two parallel aspects of one essence which is not knowable in itself,' or, in a more positive variation, 'one reality' which is known precisely in its 'two aspects'? This is one of the forms of 'monism' that is still very widespread in our times. But we can by no means come to a

69. Bogdanov expands this discussion and his sympathy to Ostwald's theory in Book 3 chapter 7.2 Energetics and Empiriocritisism.

halt at this point of view. We cannot do so if only because we consider it not monist but dualist. The uniting of the two 'aspects' and the two methods of cognition of them in the one word 'reality' does not seem to us to be a real unification at all. From our perspective, two methods of cognition can mean only dualist cognition, and two 'parallel aspects' is only a poor metaphor from geometry

...A 'living being'—a 'person,' for example—is, first and foremost, a definite complex of 'immediate experiences' (Bogdanov 2020, 90).

This monism might be an inspiration for Rovelli ('flash facts' see below) and:

The 'environment' is what presents itself to us in perception and cognition as the 'inorganic world.' At this point I must remove unnecessary misunderstandings. In our experience, the inorganic world is not a chaos of elements but a series of specific groupings in space and time; in *our cognition* the inorganic world is even transformed into a harmonious system, united by the continuous regularity of relationships (Bogdanov 2020, 95).

In his long expose in Book 3, Bogdanov distances himself from Mach and writes:

In my general philosophical conception, I have taken only one thing from Mach: the idea of the neutrality of the elements of experience in regard to the 'physical and the 'psychical,' the idea of the dependence of these characteristics only on how they are *connected* in experience. Subsequently, in all that follows—in the theory of the genesis of psychical and physical experience, in the theory of substitution, in the theory of 'interference' of complexes-processes, in the general picture of the world that is based on these premises—I have nothing in common with Mach (Bogdanov 2020 297).

This suggests that only connected experiences are social, but the elements are immanent.

A red line in Bogdanov's work is the idea of mutually defined processes in a holistic view.

It is the immediate struggle with nature, and, in a word, it is the realm of the technological process in the fullest and strictest meaning of the word. The role of the 'organiser' who directs and coordinates the labour of such workers—whether it is the patriarch of a tribal commune, a Medieval lord, a slave-owner of the ancient world, or an entrepreneur in the era of capitalism—is different. They act on nature through the implementers, but—to the extent that they are indeed organisers and not implementers—they do not enter into the immediate struggle with nature (Bogdanov 2020, 367).

Summarising the connection and correlation between 'ideology' and 'technology' in the process of social development, we arrive at the following formulations:

1. The technological process is the realm of the immediate struggle of society with nature; ideology is the realm of organising forms of social life. In the

> final analysis, the technological process presents precisely the content that is organised by ideological forms.
>
> 2. Consistent with such a correlation, the technological process represents the fundamental realm of social life and social development, and ideology represents a derivative realm of social life and development. Ideology is energetically conditioned by the technological process in the sense that it arises and develops on account of the inherent preponderance of assimilation over disassimilation in it. From the qualitative aspect, the material of ideological forms also has its basis in the technological realm.
>
> 3. The development of technological forms is accomplished under the immediate action both of 'extra-social' selection (the influence of external nature) and also of social selection. Development of ideology is directly subject only to social selection.
>
> 4. The starting point of any social development lies in the technological process. The basic line of development goes from technological forms through the lower organising forms of ideology to higher ones. Correspondingly, the growth of conservatism of social forms goes in the same direction.
>
> 5. The derivative line of social development, directed from higher organising forms to lower ones and from ideology to technology, is always only a continuation and reflection of the fundamental line. It not only does not change the relatively large magnitude of conservatism of the higher forms of ideology but it even depends on this conservatism as a necessary condition.
>
> 6. Thus, the dynamic conditions of social development and degradation—the motive forces of these processes—lie in the technological process; static conditions of social development and degradation—limiting, regulating, formative conditions—lie in ideology (Bogdanov 2020, 361).

We see here a strong technological optimism and the suggestion, then certainly popular in the early USSR, that a proper ideology can produce a political emancipation of the workers and peasants by using the engine of technology.

12B) Lenin's Reply to Bogdanov

In the context of the dreadful political situation in Russia after the suppression of the 1905 revolution, intense discussions among socialists of all stripes dealt with a series of crucial questions, such as the organisation of the small working class, the enormous backwardness and illiteracy of a major part of the population, and the role of the peasantry. It is not the place here to review this discussion in-depth, which gave context to the fierceness of the philosophical disagreements. For an early study, see (Sochor 1988), and for a recent balanced study on Lenin's famous book *What Is to Be Done* (*Chto delat?)* 1902*,* see (Lih 2008)

The main issue was and still is not deep philosophical discussions, but about the building of strong class organisations to fight Czarist feudalism (or today, capitalism in all its forms). Secondary, the issue also remains the battle against religion and utopianism. For Lenin, party building, as a form of workers' power against authoritarian suppression, is indispensable. Note that in those years, despite the later day claim of an enlightened path, led by a mastermind that leads conclusively to a glorious victory (cf. Stalin, Mao, Kim) the Bolshevik party then was far from homogenous. In Lenin's discussion with the 'Machians', Lenin tries to conceptualise the central issues in terms of a revolutionary Marxism against the various reformist currents in the social democracy at large. In line with Marx and Engels, it is the notion of scientific socialism as a programmatic *Leitmotiv*.

This, without ever elaborating the notion of 'science' as such, and the idea that science is the field where we find truisms. In hindsight, we have to realise that at the turn of the twentieth century, the natural sciences were considered more or less complete; only after two decades in the new century, the whole classical edifice broke down. This means that the discussion on scientific truth and reality between Lenin, Bogdanov, and co-thinkers is certainly not final. As argued above, the resemblance between a contextual phenomenon in nature, our physical sensation, and our linguistic understanding of that sensation are not fixed; pure human experience is expressed in ever changing, often metaphoric, language.[70] In quantum mechanics (see below), this is a major issue, as e.g., an atomic physical effect is measured (seen) by macroscopic apparatuses.

In my view, the dynamics of science and consequently the difference between scientific facts (that what we experience (measure) and grasp in the context of a mature theory) and more general overarching world-views such as formal logics or Hegelian-inspired dialectics, is a never-ending story, as world-views constrain or enable wider perspectives.[71]

In a very short period in 1908, Lenin wrote his angry polemic *Materialism and Empirio-Criticism: Critical Comments on a Reactionary Philosophy* (Lenin 1908)[72]. The book deals primarily with the foundational issue of materialism in the line of Frederick Engels's *Anti-*

70. Take the example of falling on the ground due to gravity. In modern terms, we say that gravity is not a force but the consequence of the bending of space time. (see for a nice explanation: https://www.youtube.com/watch?v=R3LjJeeae68) Now also that might be not the final scientific 'truth,' as an old theory called 'teleparallel gravity,' is still a contender, and this might give a clue to quantum-gravity which in its present form is ontologically problematic, as quantum mechanics 'lives' in flat space whilst gravity in curved space.

71. It is here that I content that the strange idea of a 'Theory of Everything' is pure religion. The term everything only encompasses what we know now.

72. As the book had to pass the Czarist censor, Lenin asked his sister Anyuta in a letter of November 8, 1908 to replace in the final proof the term popovshchina (a derogatory term for clericalism) to the term Fideism, which in epistemology means a faith independent of reason. At present, many people still wonder about this obscure term. https://www.marxists.org/archive/lenin/works/1908/nov/08au.htm .

Dühring (Engels 2010a [1878]), and his *Ludwig Feuerbach and the end of classical German philosophy* (Engels 2010b [1886]. Note that Engels's notes on science collected in his *Dialectics of Nature* (Engels 1873–1882), only became available after Lenin's death. In a remarkable *tour d'horizon* on contemporary science and philosophers of science, Lenin defines a materialist worldview: the notion that nature exists before, during, and after the existence of humans and that the human knowledge of nature, needed to survive as a species, is always a continuing re-evaluation and redefinition of scientific findings. Attacking empiriocritisism in his first chapters, chapter five deals with the novel breakthroughs in physics in particular atomism and the electron as what was then seen as the smallest building block of nature, as well as radioactivity, that is to say the transmutation of chemical elements. In his last chapter, he confronts empiriocritisism with historical materialism. Much can be said about the backlash this foundational polemic received after its increasing canonisation since the late twenties, following Lenin's death. On the one hand, this lead to the infamous Stalinist tradition of what one can only call Talmudism, and on the other hand becoming the bullseye of anti-communist attacks.

For that reason, in appreciating Lenin, we have to go back to the core of the issues at stake and review them seriously.[73]

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73. For years the solid overview and attack on the latter day's Soviet philosophy by the top Jesuit pundit Gustav Andreas Wetter S.J. (1911–1991) was a standard reference in western Diamat studies (Wetter 1958). "More especially does the author believe that only a more detailed account can justify his opinion that in present day Soviet philosophy there is very little left of real dialectics, and that it consists, rather, of a materialistic evolutionism, decked out in dialectical terminology?" (page xi). It is a thorough study including discussing Bogdanov: "The 'substitution' is made possible for empiriomonism in that it conceives of all being, the whole of reality, as a continuous chain of development, whose lowest members are still lost in a 'chaos of elements,' while the highest represent human experience, mental and individual in the first place, and later social and physical. The highest point of development is reached in physical experience, since it requires, as already stated, the organization, not merely of individual, but also of collective experience. Bogdanov thereby thinks himself able to preserve that primacy of the physical over the mental order which is incumbent on any form of materialism" (p. 94). In this new development Bogdanov sets out from one of the theses which Marx had advanced against Feuerbach... Philosophy as a contemplative inquiry must be abandoned in favour of a constructive science of organization (or Tectology)… It is not concerned merely to 'explain" the world. Though it does in fact explain how elements of the most various kinds are combined in Nature, labour and thought, its primary concern is with the practical mastery of all these various possibilities of combination. It is wholly preoccupied with practice, knowledge itself being regarded as merely a special case of practical organization, the coordination of a special of practical organization, the co-ordination of a special class of complexes.

Hilarious is the defamatory reply by the (not yet) important DDR thinker Georg Klaus (1912–1974) (Klaus 1958): E.g., "Der Personenkult und die Anerkennung unfehlbare Persönlichkeiten sind der katholischen Philosophie wesenseigen, dem Marxismus-Leninismus aber wesensfremd. (Klaus 1959, 114). "Bogdanov war subjektiver Idealist, und seine Theorie de Wahrheit ist subjektiv-idealistisch… Ein Urteil kann nach Auffassung

Lenin attacks with long quotations from the empirio- and -monist critics and compares Mach and Avenarius's thinking with that of George Berkeley (1685–1753).[74] This latter thinker decreed that only 'conscious things' exist, and in his *A Treatise Concerning the Principles of Human Knowledge*, Part I (1710), he brought all objects of sense, including tangibles, within the mind; he rejected material substance, material causes, and abstract general ideas; he affirmed spiritual substance; and he answered many objections to his theory and drew the consequences, theological and epistemological. He became the prototypical anti-materialist.[75]

At the occasion of Berkeley's bicentennial Karl Raimund Popper (1902–1994) wrote a paper 'A Note on Berkeley as Precursor of Mach', a mirror image of Lenin's critique, written (obviously) without mentioning the latter (Popper 1953).

The essence of the issue is the debate over a full split between thinking and matter (a la Descartes), a monist approach that thinking and sensations are two concurrent tracks like a rail track that demand a common methodology (Bogdanov), or a claim that:

> This is materialism: matter acting upon our sense-organs produces sensation. Sensation depends on the brain, nerves, retina, etc., i.e., on matter organised in a definite way. The existence of matter does not depend on sensation. Matter is primary. Sensation, thought, consciousness are the supreme product of matter organised in a particular way. Such are the views of materialism in general, and of Marx and Engels in particular. (Lenin 1908, 55)

And:

> Their denial of matter is the old familiar answer to epistemological problems, which consists in denying the existence of an external, objective source of our sensations, of an objective reality corresponding to our sensations (Lenin 1908, 151)
>
> If "elements" are sensations, then the dependence of physical elements upon one another cannot exist outside of man, and could not have existed prior to man and prior to organic matter. If the sensations of time and space can give man a biologically purposive orientation, this can only be so on the condition that these sensations reflect an objective reality outside man: man could

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der Marxismus -und jeder echten Wissenschaft—selbstverständlich auch dann wahr sein, wenn der größte Teil der Menschheit es für falsch hält." (Klaus 1958, 41). The irony of history is that Klaus became one of the top protagonists of Cybernetics in the 1960s in the DDR.

In a separate paper (Wetter, 1960), Wetter deals with the debates on quantum mechanics and general relativity theory in the former USSR.

74. See for an overview e.g. https://www.britannica.com/biography/George-Berkeley and https://en.wikipedia.org/wiki/George_Berkeley

75. Interestingly always positively named by this followers and derogatory by his adversaries as **Bishop** Berkeley. Only about two decades after written his main philosophical treaties he was consecrated as Bishop of Cloyne in 1734.

> never have adapted himself biologically to the environment if his sensations had not given him an objectively correct idea of it. The theory of space and time is inseparably connected with the answer to the fundamental question of epistemology: are our sensations images of bodies and things, or are bodies complexes of our sensations? (Lenin 1908, 184).

Against Bogdanov's claim that objectivity is 'socially-organised experience,' Lenin writes as a counterexample:

> Catholicism has been "socially organised, harmonised and co-ordinated" by centuries of development; it "fits in" with the "chain of causality" in the most indisputable manner; for religions did not originate without cause, it is not by accident that they retain their hold over the masses under modern conditions, and it is quite "in the order of things" that professors of philosophy should adapt themselves to them. (Lenin 1908, 125)

As argued above, we have to be careful what meaning we attach to words and certainly in the case of tangible matter (stuff), matter as defined in physics theories (see above), matter as source for gravity in the case of 'dark matter' where we observe unexplained gravity and hence call it dark, because we don't see it but only infer. If our theory is complete, there must be matter, though we cannot see it. This brings us to what we call matter as a category:

> If you hold that it is given, a philosophical concept is needed for this objective reality, and this concept has been worked out long, long ago. This concept is matter. Matter is a philosophical category denoting the objective reality which is given to man by his sensations, and which is copied, photographed, and reflected by our sensations, while existing independently of them. (Lenin 1908, 130)

> In the theory of knowledge, as in every other sphere of science, we must think dialectically, that is, we must not regard our knowledge as ready-made and unalterable, but must determine how knowledge emerges from ignorance, how incomplete, inexact knowledge becomes more complete and more exact. (Lenin 1908, 102)

Liters of ink have been spilt on Lenin's 'reflection' theory to prove that his metaphor that reality is mirrored in the brain is nonsense. I contend that Lenin was well aware that copies and photos are no homomorphisms[76] but metaphors (now people play with the concept of hologram), metaphors with content that changes over the years. The issue at stake, as argued in the introductory part of this paper, is that the more we know, the more variance we see in our metaphors and the wider we have

76. A homomorphism is a map (projection) between two algebraic structures of the same type (e.g., two groups, two fields, two vector spaces), that preserves the operations of the structures.

to throw out our fishing net (to quote Eddington).[77] For many, the intrinsic uncertainty about a world that gives rise to humankind, a species that has to live in accordance with the rules of nature but is in an ever-during process to grasp how to formulate those rules, is terrifying. It is here that the rescue boat is seen in religion or in reduced formal theories that—as far as we experience—face fully describable observations. It is science that tries to get a grip, and more than once.

A second issue, next to philosophical materialism, is the Marxist use and development of the notion of dialectics, the mutually creative interactions of 'somethings.' It is outside this paper to go into details, but it is important that Bogdanov does not discuss dialectics at all, worse in his tektology (as well as in his sci-fi novels, he strives towards equilibrium). On the other hand, Lenin is often attacked for having a too vulgar a notion of dialectics; in his case, the notion of a unity of oppositions was the pivot. Also here much ink has been spilled, in particular because Lenin's philosophical notebooks, which in their entirety were only published as from 1933 (Lenin 1972). We see the same kind of discussion as we have seen in the 1960's about the perceived split in the thinking between the young and the old Marx. The question here is 'when did Lenin read Hegel?' And are the *Notebooks* an improvement of the polemic *Materialism and Empirio-Criticism*. This issue is well tackled by (Kouvelakis 2007).

So, the debate between Bogdanov and Lenin remains of interest, but only if we discuss it in the context of the ongoing debate of the what fundamental stepping stones we need in building an emancipatory theory and movement that integrates the ongoing debates in the sciences as metaphors and guiding rails for politics. Not the other way around. We often see popular texts which try to explain the world according to some complicated (mathematical) theory suggesting that the marvels of some theory is considered the absolute truth. It is here that quantum mechanics enters the arena.

13) And Now for Something Completely Different: Quantum Mechanics

In this section, we try to address quantum mechanics without mathematical formulae. This is difficult because quantum mechanics is cast (*begreifen*) in mathematical language, because we cannot understand (*verstehen)* what is going on.

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77. Eddington (1939) famously gave the metaphor: "If (1) No sea-creature is less than two inches long. And (2) All sea-creatures have gills. Then as both are true for one catch, and we assumes tentatively that they will remain true however often we repeats hauling a fishing net." In applying this analogy, the catch stands for the body of knowledge which constitutes physical sciences, and the net for the sensory and intellectual equipment which we use in obtaining it.

Quantum mechanics is the descriptive pragmatic theory of the smallest energetic steps we encounter. Until the beginning of the 20th century, classical mechanics was able to describe and forecast phenomena very well. This is due to an essential feature: descriptive mathematics deals with so-called 'smooth' functions, which means that changes can be—in principle—continuous and infinitely small. Smoothness is also an essential feature of relativity theory, the theory that, in its so-called 'special form', has the extra postulate that the velocity of light has a finite value everywhere (see note 32). In 1900, Max Planck pondered the energy emission distribution of a hot black body.[78] Plank tried to find a formula that describes the changing energy distribution over the frequency range. He could only come to a description when he introduced the then-heuristic assumption that the energy was not distributed smoothly, but that the energy must be thought of as being in finite packets: quanta. A second ingredient towards quantum mechanics is the notion of a spectrum. When light (electro-magnetic radiation) is emitted from a hot object (e.g., by metal particles in the flame of a fire), we see only well-defined frequencies (colours) which are not evenly distributed over all colours. It became more and more known that different substances absorb or emit different colours, e.g., the yellow light of sodium lamps or the more bluish from mercury lamps used as street lights. In studying the spectra of pure atoms (e.g., in a flame), a regular pattern of (emission or absorption) lines was found against a dark background.

In 1905 Albert Einstein used Planck's 'quantisation' of energy to solve two outstanding riddles: the behaviour of the specific heat of a solid at very low temperatures and the photo-electric effect. The last effect entails that if we shine light on a (metal) surface, at only larger than a certain critical energy (colour) of the light, an electron is emitted from the surface independently of the intensity of the light. This showed that at a particular energy only, namely equal to the binding energy of the electron n the surface, an electron became 'energised' to escape. This proved that indeed energy is quantised as a matter of fact and not as a heuristic tool.

In the same period experiments showed that the atoms of the chemical elements were a whole world in themselves. We found a positive small nucleus and on distance a cloud of negative 'electrons' (what is positive or negative is a convention). In 1913, Niels Bohr invented the planetary model for the atom in which he postulated that the electrons circle in well-defined discrete trajectories (or orbits) around the nucleus

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78. For a body in equilibrium with its environment the absorption and emission of electromagnetic radiation are equal. Bodies that are conceived perfect absorbers of radiation are called ideal black bodies, because they look black. Each body above zero temperature emits electromagnetic radiation (light), and the 'black-body' radiation curve for different temperatures peak at different wavelengths and are inversely proportional to the temperature.

(like the planets around the Sun). As we know, a circling electric body must lose energy, but then the circling electrons would lose their energy very quickly. Bohr stipulated that the discrete orbits of the circling electron must be stable, but that if an electron (due to some energetic effect) was 'jumping' from one orbit (formally called state) to another, a certain well-defined quantum of energy was ejected or absorbed in the form of a light 'particle' (later named photon) with equal energy (colour) of the energy difference between that orbits. In this model, the steps from lower to higher orbits, called excitations, are allowed until the electron is so far from the nucleus that it 'leaves the atom' —in other terms, the atom gets ionised (by ejecting this electron), gaining an electric charge of one electron less than before.

For years, precise measurements showed that we have regular steps in the transitions, and even more remarkably, these steps turn out to always be a multiple of Planck's elementary quanta, which could be interpreted as 'jump' for a certain 'states' to another 'state,' visualised as spectral lines. And it was now proven that we always deal with discrete energy transitions between stable states (originally named orbits) and not by a smooth transfer of energy at the atomic level. The Bohr model explained why we see discontinuous spectral lines. This way, a model could be designed for a situation that could be pictured as electrons that 'circle' (in elliptic paths) in various 'shells' around the nucleus, whose energetic distance was a multiple of the Planck's quantum, named *h,* squared, starting from any perceivable two orbits of electrons, we got a clear series of frequencies. It was Einstein's work from 1916/7 that the absorption or emission of radiation to and fro two energy levels could be described as a distribution like the distribution of Planck's black bodies. Given a full quantum mechanical derivation of Planck's derivation. Already then, the notion of probability came into the game. Here 'h' is introduced as an action (energy per second).

In other words, not only is the velocity of light (in a vacuum) a constant, but it is also the minimum unit of action for a certain frequency (the famous expression h*v).* Now we enter the world of granularity: *quo vadis*?[79]

14) The Formal Languages of Modern Quantum Mechanics

Within a couple of years the Bohr planetary model was overtaken by pure mathematical constructions cumulating into the foundational mathematical structure invented by Paul Adrien Maurice Dirac (1902–1984). We now drop all visualisation and talk about 'states' and vectors (objects with a direction and a magnitude) (Dirac 1978).

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79. For a non-technical introduction book without maths and written in simple but clear straight language, tread Anton Zeilinger's book *Dance of the photons* (Zeilinger 2023)

It was in 1925 that young Werner Heisenberg, on holiday on the northern German island of Helgoland, invented the steps toward modern quantum mechanics. This is the story of Rovelli's book *Helgoland* (Rovelli 2022a). Heisenberg played with the various series of experimentally found transitions of electrons from one state to another and put them into tables.

He decided to make a theoretical framework that would only contain observable quantities. That is to say, quantities that can be inspected directly, or indirectly with the help of a measurement apparatus, by our human senses. As far as atoms go, he stated that what we can and do observe are only the frequencies and the intensities of the spectral lines, whilst the orbits of the electrons are unobservable and therefore the calculation of these should not be the goal of the theory. Heisenberg then proceeded to 'guess' his theory with the help of Bohr's correspondence principle. Bohr, the doyen of the field, insisted that every measurement must be understandable in terms of macroscopic devices, since, according to Bohr, we humans only perceive macroscopically; consequently, there must be a point where a quantum approach is indistinguishable from a classical continuous approach.[80] This will happen when on a very high level of electron excitation, where the energetic distances between states become increasingly small. Bohr postulated in 1918 that for large quantum states and small transitions between those states, a close relationship between the yet to be calculated frequencies and intensities and what could be calculated classically. Heisenberg then extended *ad fiat* this correspondence principle to all transitions and 'translated' the classical result into quantum mechanical language. (Heisenberg called this translation *Umdeutung* or re-interpretation). As we said above, transitions are dependent on two states, call them n and m. Heisenberg ended up with two-index square arrays, with in the column the various values of n and the rows those of m.

The entries were rows and columns cross named 'q_{nm}' are defined as transition amplitudes (strength). The square of these entities is related to Einstein's transition probabilities from a 'state' n to m.[81] The correspondence principle required that these entries q_{nm} are related to classically amplitudes (the extent of a vibration or oscillation, measured from the position of equilibrium), which are a measure of the relative intensities of the emitted electromagnetic waves.

Now on these crossing point in the table, named $q_{nm.}$ Heisenberg listed the to be observed intensity of the transition (spectral lines). It turned out that his description of the transitions could be seen as a

80. It is still an open question if Bohr is right and humans cannot experience single quantum objects as being macroscopic objects themselves. Rovelli is following Bohr here.

81. A state can be seen as a mathematically well-defined situation. An orbit is a more pictorial name for a circling particle around another particle. The letters n and m are just counters without physical meaning.

mathematical matrix and remarkably accurate. As mentioned above, matrix manipulation is not communicative (non-Abelian) and X times Y is different than Y times X. The elements of the matrix can be seen as an amplitude, the square of which gives a numerical probability of the value of the transition: this is the famous Born rule named after his inventor Max Born.

The mathematics of matrices was not widely known in those years and it took some time before Max Born (1882–1970), Ernst Pascual Jordan (1902–1980), and Heisenberg established full matrix mechanics as the novel approach to quantum mechanics. The upshot of this model is that we talk about all possible transitions between physical states of quantum mechanical objects without a pictorial notion, such as an electron orbiting an atomic nucleus, hence the neutral term state. It is a full mathematical approach with a limited number of rules, and hence, for many people, completely abstract (*Unanschaulich* in German).

A key element is the mentioned notion of correspondence. That is to say that every measurement must be understandable in terms of macroscopic devices. As said, this will happen when on a very high level of electron excitation, where the energetic distances between states become increasingly small, so that we can equate the classical state with the quantum state. Heisenberg took the bold step that also the q_{nm} values should be solutions of the (classical) equations of motion. Solving these equations gives the quantum mechanical amplitudes and therefore the transition probabilities, which are equated to the intensities. A higher probability reflects a higher intensity. Heisenberg also gave rules for how to manipulate the square arrays q_{nm}, which led Max Born to the observation that these arrays are what mathematicians call matrices. The *Umdeutung* of the position (place) q_{nm} was extended to the *Umdeutung* of the momentum p_{nm} (momentum is the name for the quantity of motion of a moving body, measured as a product of its mass and velocity). Heisenberg also translated Bohr's quantisation condition, i.e., that the action is a multiple of h (which selects the allowed orbits or states), which led to the well-known commutation relation between position and momentum p_{nk} times q_{km} minus q_{km} times p_{nk} equals in mathematical sign language $[p, q]_{nn} = -ih/2\pi$. As mentioned above this means that $A \times B \neq B \times A$. P and Q don't commute.[82]

It is this commutation relation that is 'responsible' for virtually all strange quantum effects, such as the uncertainty relations and the contextuality of measured variables. With the re-interpreted position and momentum as solutions of the classical equations of motion and the commutation relations, matrix mechanics is effectively 'done' and is a

82. The letter i is defined as the square root of -1, which pops-up when we use complex numbers and π relates to the fact that we deal with waves which are represented in circular motion.

complete theory of quantum mechanics, in the sense that all observable quantities are in principle calculable without further ad hoc additions. An outstanding question is of course why and how transitions take place. This is not the place to go further into the niceties of matrix mechanics.

For the physicists of the 1920s, matrix mechanics was a highly abstract theory as it did not offer any visualisation of what was going on in the atom or what caused the transitions. For Heisenberg this was just the point of the theory. This also defines Heisenberg's positivism, which only takes 'bare' sensual experiences as relevant. By reducing the physical processes to formal mathematics, one of the obstacles becomes that we have to learn and teach the mathematics of theoretical physics before we return to understanding. Again, an example of the method of exhaustion, with which we started this paper.

To the astonishment and relief of many, in a short time, the Austrian Erwin Rudolf Josef Alexander Schrödinger (1887–1961) came in 1926 with a totally different approach in which he formulated the time development of a quantum mechanical situation in the form of the well-known 'wave-function.' Here, he followed Louis Victor Pierre Raymond, 7th Duc de Broglie (1892–1987)'s suggestion that particles should be represented by what he called a matter wave. Schrödinger invented a wave equation for these matter waves and was able to extract from it the energy levels of the hydrogen atom, which was easier this way than with the matrix approach.

Schrödinger's initial interpretation was that these waves existed as real waves in three-dimensional space, and therefore, his theory brought back visualization to the realm of quantum theory. Heisenberg was appalled by this turn of the tables. In reaction to the success of Schrödinger, he brought a sort of visualisation to matrix mechanics by formulating the uncertainty principle; this explained why (classical) visualisation can only be attained to a level that is constricted by the uncertainty relations.

However, Schrödinger's approach ran into problems with more complicated atoms. His interpretation gave way to the now accepted interpretation that the modulus squared of the wave function gives the probability to find, upon measurement, the particle in a certain position. So, the escape from pure formal mathematics failed.

Schrödinger proved that matrix mechanics and wave mechanics are mathematically isomorphic (point-to-point equivalent). Dirac and Jordan developed a formulation of quantum mechanics that embraced matrix mechanics and wave mechanics as special cases of a more inclusive vision, which they called transformation theory.

The equivalence proofs were put on solid mathematical foundations by John von Neumann (1903–1957), who gave quantum mechanics its "mathematical" home in Hilbert vector space, with its own mathematical (linear algebraic) rules.[83]

15) Confrontations

With the invention of matrix mechanics and wave mechanics, the story is not over in terms of meaning and understanding. Although quantum mechanics is doing its job without further ado, the discussion about whether this is all there is continues.

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As abstract matrix mechanics was new and wave mechanics is a well-established field in optics, it was even more remarkable that it was proven that both approaches got the same physical results in their calculations and could mathematically mapped onto each other. Now, almost everybody learns quantum mechanics, starting with the more pictorial wave mechanics; later on, the matrix approach is explicated. The only textbook that starts with the fundamentals from black body radiation towards matrix mechanics and subsequently wave mechanics is (Tomonaga vol. 1 1962, vol. 2 1966).

The story is complicated because in the matrix approach, we have a clear discrete situation, whilst in the wave approach we start out from an intrinsic, continuous situation which is actively discretised.[84] Worse, in the wave picture we are confronted with the so called measurement problem. This often popularised problem tells us that, as long as nothing happens the value of a so-called observable (the thing we can measure) is not determined. Only in the measurement a definitive value can be obtained and so the wide-ranging wave function which harbours many possible outcomes, momentarily 'collapses' to a well-defined value. All stories told in popular books about cats, observers, etc., follow from this wave mechanical picture of quantum mechanics.85 Here, the model (is the cat alive or not) explicates intrinsic issues in presenting it as marvels.

But what does it all mean? Bohr was one of the first physicists to be bothered by this question. We might say that, according to Bohr, the theories given by Heisenberg and Schrödinger are 'empty' mathematical schemes. "How can the position of an electron be a matrix?!" and "Schrö-

83. A Hilbert space (named after the mathematician David Hilbert (1862–1943), is a generalisation of Euclidean space in which, e.g., vectors, serve as objects https://en.wikipedia.org/wiki/Hilbert_space. The mathematics is conform linear-algebra, the versatile model for many phenomena.

84. It is very questionable that formally we can reduce h to zero, as is often suggested being the case in Bohr's correspondence principle, which introduces the numerical equivalence between classical and quantum descriptions. See for a discussion (Holland 1996).

85. To the present author, it is still unclear how the 'measurement' problem is unambiguous dealt with in the matrix approach. This as it is suggested that the outcome of a measurement is a pure result of probability.

dinger's wave does not exist in real space." But both schemes give excellent predictions of what is measured. What is observed, according to Bohr, are classically known concepts, like the classical notions of momentum and position: "no one has ever observed a matrix or a wave function". The limits of applicability of these classical concepts are proscribed, or better constrained, by the uncertainty relations who are intrinsic to the mathematical schemes and can be derived from them (to be precise: they can be derived from the commutation relations).This constraint is also responsible for the duality of waves and particles, or, as Bohr has shown, the interpretation of the uncertainty relations can be derived from the particle-wave duality.86 Bohr extended this observation to his notion of complementarity, which is a more philosophical way to state that quantum mechanical prediction and observation is contextual: to predict and observe one must state what we know about the object under consideration in a particular measurement context. This then in reverse, explains why indeed Schrödinger's wave is just a tool to make predictions and is not 'attached' to the object only. Heisenberg's scheme is way more radical than Schrödinger's approach, which harks back to classical notions of a 'really existing' wave, which then forces us to endlessly talk on what the collapse of this entity means. Bohr's collapse is what happens when we 'hit' the mathematical scheme in a measurement context with classical measurable concepts, through which the quantum mechanical concepts get meaning and a value. In other words we deal with an approach that denies that (sub) atomic entities have a value before we measure them with a macroscopic device. In the measurement, the circumstances induce a value out of the possible probabilities.[87]

So, we are confronted with two approaches, a more or less pictorial wave versus pure tables of numbers, with the suggestion that they are mathematical isomorphism despite the fact that the two use very different ways of *verstehen*. This forces us to consider whether we deal indeed with the same physics in various mathematical dress.[88] If so, a clear correspondence between the standard measurement problem, with a collapse of the wave function and the static representation in matrices, must tell us more. If not, we certainly have to go back to the drawing

86. The uncertainty, or indeterminacy principle is the concept that there is a limit to the precision with which certain pairs of physical properties, such as position and momentum, can be simultaneously known. In other words, the more accurately one property is measured, the less accurately the other property can be known.
87. David Bohm came with the suggestion that the measurement results might be seen as a statistical result of a lower level of a sub-quantum mechanical level (like a quantity ↔ quality transition) (Bohm 1957, chpt. IV). Just published is an analyses of Bohm important lost lecture of 1957 in which this approach is explicated. (Bohm, Gutfreund, Renn, 2025).
88. In an interesting recent paper: (Taschetto and Correa Da Silva 2024) dig deeper and try to find the fundamental reason for the equivalence of the two approaches.

board. In simple words, are two equivalent theories in terms of results indeed the same or can we detect differences in the foundations of these theories which might provide novel insights?

In the context of this paper, it must be said that although Rovelli speaks in wave function terms, his bottom line is the Heisenberg matrix approach.

Of interest is the fact that we have many different interpretations, mainly based on wave mechanics, such as a fundamental idea of probabilistic interpretation, of the so-called many world interpretation, and more importantly, from a materialistic point of view, the causal realist interpretation of David Bohm who introduces a 'quantum potential' as a physical field that determine the trajectories of real particles and is not located in a Hilbert vector space but in configuration space. This space refers to the real position of all constituent point particles of the system under review.[89]

16) What is the Rovellian Relational Quantum Mechanics (RQM) Approach, and what makes it New?

After our stroll from the certainties of classical mechanics to the uncertain outlook from a terrace on the icy slopes of mathematical models, we join Rovelli in his approach for which he finds inspiration in Bogdanov.

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Carlo Rovelli's interpretation is based on the Heisenberg approach (see above). Here I try to summarise and question his thinking as far as I see it.[90]

The main lofty ambition of Rovelli is to establish a principle theory (Einstein style, see above) based on a few postulates that encompasses the many successes of the quantum theory, the reformulation of which is needed, in particular in relation with the notion of 'observer-independent state' of a system, or 'observer-independent values of physical quantities,' suggesting that values are already fixed before we measure them as is the case in classical mechanics.

In a certain way, this looks as a coordinate independent description as we have in general relativity theory. We do have fixed values which are independent from the coordinate system we use. In quantum mechanics as the result of the mathematics we use; superposition of waves, the coordinates do play a role.

89. For the causal interpretation textbook see (Holland 1993). Strange enough we also have a group of researchers who call themselves "Bohmian" although they explicitly drop the quantum potential and have no direct relationship with Bohm himself. In fact they are following an earlier approach started with De Broglie.

90. As the present author is not a professional mathematical/theoretical physicist, he has to refrain from technical niceties but will address Rovelli's system with questions in relation to fundamental discussions on reality, materialism and empirio/monistcriticism.

Values are now established within the relation of the 'observer' and the 'observed' v.v. in a quantum system.
Rovelli's goal is:

> That quantum mechanics will cease to look puzzling only when we will be able to *derive* the formalism of the theory from a set of simple physical assertions ("postulates," "principles") about the world. Therefore, we should not try to *append* a reasonable interpretation to the quantum mechanics *formalism*, but rather to *derive* the formalism from a set of experimentally motivated postulates. (Rovelli 1996, 1637)

In other words, we don't need extra ingredients. Quantum mechanics is a complete theory that needs reformulation based on principles.
Or

> RQM does not interpret the confusion about quantum theory as a sign that what is necessary to render the theory intelligible is a new equation (as in De Broglie-Bohm theory), some not-yet observed phenomena (as in the physical collapse hypotheses), or the assumption of the existence of an inaccessible domain of reality (as the Many Worlds's universal quantum state.) Rather, it interprets quantum phenomena as an invitation to a radical update of the conceptual framework we use to think about reality. (Rovelli 2025a)

In a bit of a polemic recent paper this is formulated as:

> From Kuhn comes the idea that new scientific theories are not grounded in previous ones: progress instead comes about through 'paradigm shifts,' the scientific equivalents of revolutions. Popper, meanwhile, supplies the notion that a theory is scientific only if it is 'falsifiable': if it can be proved wrong by empirical evidence. Superficial readings of Popper and Kuhn, I think, have encouraged several assumptions that have misled a good deal of research: one, that past knowledge is not a good guide for the future and that new theories must be fished from the sky; and two, that all theories that have not yet been falsified should be considered equally plausible and in equal need of being tested. The history of science suggests that such attitudes are wrong-headed. It is difficult, if not impossible, to think of a major advance in fundamental physics that has emerged from arbitrary hypotheses. They have instead come from two sources, both empirical. The first is new data… The second source of advances is the study of apparent inconsistencies or incoherencies in established knowledge: taking this knowledge seriously, and trying to make it consistent. (Rovelli, 2025b)

Apart from a questionable interpretation of the thesis of the logical positivist Kuhn (1994 [1962]) and the wide-ranging debate about his thesis or the many discussions of the issue by Popper, who had much to say about quantum mechanics (e.g. Popper 1982 and later), Rovelli concludes with:

> New knowledge will come when new data are shown truly not to fit with what we know; or by reflecting in depth on what established theories, such

> as general relativity and quantum theory, imply when taken together. (Rovelli 2025a)

This, in my view, does allow reflections on, e.g., Popperian propensities, and suggests that the merger of established theories is not a scientific revolution, but more a kind of 'shut up and calculate.'

The denial of scientific 'revolution' severely restricts the role of 'wild ideas' such as curved space, a quantum potential, or action at a distance, the heliocentric worldview, as well as the very invention of the quantum of energy by Planck. This is certainly unfortunate, as it is in the confrontation of worldviews that science progresses. Rovelli's goal is to reformulate the established knowledge within the boundaries of that theory.

> QM is a radical attempt to cash out the breakthrough that originated the theory: the world is described by events or facts described by values of variables that obey the equations of classical mechanics, *but* products of these variables have a tiny non- commutativity that generically prevents sharp value assignment, leading to *discreteness*, *probability*, and to the contextual, *relational* character of value assignment (Rovelli 2022, 1066).

But on the other hand:

> RQM is nothing else than a minimal extension of the textbook Copenhagen interpretation[91], based on the realization that any physical system can play the role of the 'observer' and any interaction can play the role of a 'measurement': this is not in contradiction with the permanence of interference through interactions because the 'measured' values are only relative to the interacting systems themselves and do not affect third physical systems (Rovelli 2022, 1060).

Here Rovelli refers to the dogma of Bohr that a measurement is a macroscopic event. Rovelli makes very strong and important statements with:

> **Hypothesis 1**. All systems are equivalent: Nothing a *priori* distinguishes macroscopic systems from quantum systems. If the observer O can give a quantum description of the system S, then it is also legitimate for an observer P to give a quantum description of the system formed by the observer O. (Rovelli 1996, 1644)

And

> Finally and most importantly, I maintain it is reasonable to remain committed, up to compelling disproof, to the golden rule that all physical systems

91. Be aware that there is no clear cut Copenhagen interpretation, and there is a deep divide between Bohr and Heisenberg. See (Beller, as from chapter 8) and (Howard 2020) and references therein.

> are equivalent in respect to mechanics: this golden rule has proven so overwhelmingly successful that I am not ready to dismiss it as long as there is another way out. (Bogdanov 2020, 1645)

On the one hand, you can say that this holistic idea of one nature is most welcome, but the restriction to mechanics (for all practical purposes) is questionable, but maybe he means quantum mechanics only. Because after all, we already have three mechanics of which classical and GRT join forces, whilst QM plays in another league, it is not continuous but granular.

Rovelli declares "all physical systems are equivalent," but overlooks (?) the implicit notion of causality and the asymmetry of interactions. Which means that you define a mutual interaction as timeless. Certainly, such an approach rejects dialectics and tends toward a stable equilibrium situation with some minor fluctuations.
It denies quantity ↔ quality transitions and emergent properties.[92]

> **Hypothesis 2** (Completeness). Quantum mechanics provides a complete and self-consistent scheme of description of the physical world, appropriate to our present level of experimental observations.

This is the Heisenbergian claim of the completeness of the theory, which is defined within a Hilbert vector space and mathematically correct, but does it cover all possible physics and physical theories?[93]

In discussing completeness, it is worthwhile to go back to the mathematician von Neumann, who, in his foundational book, discusses the possibility of extra parameters, known as 'hidden variables.' That is to say the question of whether the theory can be augmented.

> Whether or not an explanation of this type, by means of hidden parameters, is possible for quantum mechanics is a much discussed question. The view that it will sometime be answered in the affirmative has at present some prominent representatives. If it were correct, it would brand the present form of the theory provisional, since then the description of states would be essentially incomplete. We shall show later (IV.2) that an introduction of hidden parameters is certainly not possible without a basic change in the present theory. (von Neumann 2018, 136ff)

So, contrary to common wisdom, even von Neumann allows hidden variables, provided we change the indeed closed formulation in Hilbert

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92. A typical example is that the roles of use-value and exchange value defined in the analyses of the capitalist mode of production. A mode of production which is surpassed in Bogdanov's sci-fi novel *Red Star*.
93. The completeness is also a big issue in the famous study (Beller 1999).

space. This point was already made by the German neo-Kantian mathematical physicist, socialist political activist, and educator Grete Hermann (1901–1984).[94]

Only after David Bohm in 1952 broke the von Neumann's spell with his causal interpretation which shot a hole in von Neumann's interpreters claim that von Neumann proved hidden variables impossible. The debate changed, leading to the milestone of John Bell's famous theorems, opening up a study of so-called non-local hidden variable theories.[95]

The question to Rovelli is therefore why he so apodictically addresses the suggestion in his hypothesis 2 that the standard theory is final. In the same vein, we can question Rovelli about why he, in his papers, always talks in wave function language whilst being a staunch defender of Heisenberg's approach. This can only be accepted if both approaches are completely equivalent, not only in their mathematical reduction, but also in their consequences and meaning. This poses the question of the relationship between a wave function's collapse and a probabilistic result.

Most clearly, he stipulates matters in his last comprehensive contribution, which also serves as an answer to his commentators:

> It is instead based on an ontology of physical systems and physical variables, as is classical mechanics. The difference with classical mechanics is double (a) *variables only take value at discrete interactions* and (b) the value a variable takes is only *relative* to the (other) system affected by the interaction. Here "relative" is in the sense in which, in classical mechanics, velocity is a property of a system relative to another system. These relative events occur at discrete times, and consist of physical variables taking on precise relative values; these variables may lack any value at all in intermediate times. At least in some readings, as discussed below, this leads to a radical perspectival antifoundationism (Rovelli 2025a).

Rovelli poses the basic idea to solve the measurement problem is his notion of facts.

> RQM interprets quantum mechanics as a theory about physical *events of facts*. The theory provides transition amplitudes …. for a fact (or a collection of facts) *b* to occur, given that a fact (or a collection of facts) *a* has occurred. Facts are the independent variables of the quantum transition amplitudes. …..Classical mechanics can equally be interpreted as a theory about physical

94. See: (Crull and Guido Bacciagaluppi. 2017, Chapter 8 Grete Hermann's Lost Manuscript on Quantum Mechanics. Chapter 14 Grete Hermann, Determinism and Quantum Mechanics). Herman also had an influence on Heisenberg as he refers to discussions with her, see (Heisenberg 1972 chapter 10: Quantum mechanics and Kantian theory, and, Crull and Guido Bacciagaluppi. 2017. Chapter 15, Grete Hermann, Natural-Philosophical Foundations of Quantum Mechanics.

95. For a very readable, non-technical, explanation of the Bell inequalities (Zeilinger 2023) in particular the appendix by A. Quantinger.

> facts, described by values of physical variables (points in phase space). But there are three differences between quantum facts and the corresponding facts of classical mechanics. First, their dynamical evolution laws are genuinely probabilistic. Second, the spectrum of possible facts is limited by quantum discreteness (for instance: energy or spin can have only certain values). Third, crucially, facts are *sparse* and *relative*. Facts are sparse: they are realized only at the interactions between (any) two physical systems. This is the key physical insight that we can take from Heisenberg's seminal papers, and is a basic assumption of RQM. Facts are *relative* to the systems that interact. That is, they are *labelled* by the interacting systems. This is the core idea of RQM. It gives a general and precise formulation to the central feature of quantum theory, on which Bohr has correctly long insisted: contextuality. (Rovelli 2022, 1057)

It is easy to immediately spot the Machian basis that only a sensory experience (labelling by interacting systems -which is, by the way, always contextual) gives us a fact of the world around us. Here, it is generalised towards the relation of the observer (physical system 1) and the observed system (physical system 2) if they interact. These very fast mutual interactions, he names this *flash* ontology*,* as the quantum interactions are almost immediate and the (he calls this) *relative fact* is short living. This is in contradistinction to *stable facts* that are the macroscopically retrieved values. We hear an echo of Bogdanov's credo that only connected experiences are social, but the elements are immanent.
Some questions now come to the fore.
Q1) Given the vibrant situation at the quantum level, these facts, which Rovelli names *sparse,* can be, in fact, possibly unique, but certainly more like a rapid-fire gun. At present, we have already attosecond spectroscopy, which means we can measure electron correlation effects on the scale of 10^{-18} seconds. This forces the notion of macroscopic objects [Bohr's central theme -JK) down to the atto sphere. How do we deal with the many 'sparse encounters' between quantum objects and their averaging out to measurable values in the Bohr sense? Obviously, compared with classical physics, where we have infinite values, there are fewer values due to the discreteness of values.[96]

Q2) Rovelli introduces the notion of information as a concrete tool and postulates:

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96. Immediately the metaphor pops-up with the notion of the number line. What is infinity, and do we have more infinities? Indeed, the natural numbers (1,2,3…) are infinite. But the relational numbers (x divided by y) are even more infinite as between any to natural numbers we can locale again an infinite series of fractions. So how sparse is sparse? It can only be seen in the way that discrete facts are less in number than continuous facts, but both can still be infinite. In the situation of 'quantum jumps' between atomic states, the situation is different, as we don't see a continuous spectrum. If we see the 'splitting-up' of a spectral line (so-called degeneration), then this effect is seen as the result of physical interactions, such as a magnetic field: discontinuity remains.

> Postulate 1 (Limited information). There is a maximum amount of relevant information that can be extracted from a system.
>
> Postulate 2 (Unlimited questions). It is always possible to acquire new information about a system.
>
> Postulate 2 is true to the extent that Planck's constant is different from zero: in other words, for a macroscopic system, getting to questions that increase our knowledge of the system after having reached the maximum of our information implies measurements with extremely high sensitivity. Since the amount of information that O can have about S is limited by Postulate 1, when new information is acquired, part of the old relevant information must become irrelevant. (Rovelli 1996, 1658)

Which can also be interpreted to say that after a value is obtained by a wave function collapse, the whole situation is different and hence we cannot make repeated measurements in which the second makes use of the result of the first.

Rovelli spends ample time discussing the formal theory of information, but again takes a positivist step in "freeing" information from meaning.

This is a dangerous step in my opinion, as considering labelling information is not different from introducing a coordinate system. Then the physical effect is reduced to a neutral measure. In a previous paper (Kircz 2023), I showed that, e.g., time is a measure only of the more difficult to grasp notion of change.

A last issue is the issue of reality, as Rovelli defends himself in various places against solipsism. This also has to do with the issue of how the relation is between different observers, also known as Wigner's friend, after the mathematician Eugene Paul Wigner (1902–1995).[97]

Most importantly, is that Rovelli, just back from Bogdanov's *Red Planet,* stipulates:

> For RQM, the lesson of quantum theory is that the description of the way distinct physical systems affect each other when they interact (and not the way physical systems 'are') exhausts all that can be said about the physical world. The physical world must be described as a net of interacting components, where there is no meaning to 'the state of an isolated system,' or the value of the variables of an isolated system. The state of a physical system is the net of the relations it entertains with the surrounding systems. The physical structure of the world is identified as this net of relationships. (Rovelli 2025a)

After all, this is not that revolutionary, as many Marxists - and not only Marxists - insist on a holistic approach of investigating nature.

97. This technical but important issue is complicated, and hence I refer to a clear video of my preferred lecturer. https://youtu.be/v1wqUCATYUA

17) Questions to Rovelli

After an attempt to review the long battle between historical materialism and positivism. The final step is to invite Carlo Rovelli to explicate his reasoning as well as the societal implications of his standpoint.

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A pertinent question to Rovelli is why he is very negative about Schrödinger in his presentations but keeps using the notion of wave functions and their ambiguities?

A second related question is about the dynamics of measurements. In the wave picture we can envision a situation where a probability wave is hoovering like a dome over measurement apparatuses and for some—yet unknown—reason, one measurement is selected, which immediately evaporates the probability wave and spits out a definite value. In the Heisenberg approach we have an array of possible outcomes, but also here the question why one result is finally obtained remains open. To conclude that we only have probabilities between static states without any knowledge of how these probabilities come on stage, is indeed a consequence of Heisenberg's positivism. The 'input' to his matrixes are after all only observables (see section 14 above). We only know after it happens,[98] a total denial of dynamical causality, and therewith of forecasting. This opens the door to all forms of obscurantism and arbitrariness. Consequentially, in social terms, social communal action and culture become void of a goal and meaning, but only an eruption of anger. This was a concern of Lenin, and still is a concern of many people

A third, more general question is whether Bohr is indeed correct that we are only able to talk about macroscopic measurement results in the sense that a plurality of *flash events* merge into a real fact? Obviously, a quantum effect cascades towards a moving pointer of e.g., a voltmeter (after being cached by a photomultiplier). But if an X-ray quantum precisely damages a chemical unit in a human cell (e.g., DNA), and starts a cascade towards a severe cancer, can we then still argue that we only consider the ultimate tumour?

18) Conclusion

The main issue is not that diverse perspectives of the same object or happening exist. The historical approach, which Bogdanov and Rovelli adhere to, is that our description as well as our subjective emotive feeling about something is dependent on the socioeconomic situation and its history. In Bogdanov and in a lesser sense in Rovelli, we witness remnants of a Kantian idea that there is a 'something' which we cannot approach in an absolute way. With Kant, we can agree that a well-defined something can never be ultimately better described. I disagree with Kant that this object has a certain timeless stability in our conceptual

98. Grete Hermann talks about retroactive causal relations (Crull and Bacciagaluppi, 2017).

understanding. A stone remains a stone in its most simple definition, but for people using a sling in warfare, it is definitely a different object than for a mason. Experiencing a stone is indeed primarily a sensory perception, but *verstehen* is a mental social process and both are equally real. Making the object stone communicative operational we need language, natural as well as mathematical. This grasping (*begreifen*) makes our understanding more precise in its reduction, and this reduction will become the standard in our temporary social life. A questionable aspect of Bogdanov's empiriomonism is his contention that we need one approach for the sensory physical as for the psychical.[99] This means that, although Bogdanov underwrites the historicity of our knowledge, his monism denies the various stages of transcendence in the process from physical object to contextual mental tool. A red thread in the present paper is the ever-reduction of a 'something' into a well-defined operational object. It is this type of reasoning, combined with Bogdanov's propensity for equilibrium, which gives way to his tektology. This in contradistinction to the dynamics of dialectics.

Rovelli expresses his appreciation to Bogdanov on various occasions. Unfortunately, he does not dig deep into the philosophical and historical details, which makes the present paper more a questioning than a polemic. Here, I will not deal with Rovelli's limited understanding of Lenin's dialectical thinking and historicisation of the notion of matter.

Rovelli's main appropriation of Bogdanov is his emphasis that "In these and many other cases, we understand things (organisms, chemicals, psychological life) through their being in relation to other things" (Rovelli 2022a). I contend this is obvious as well as questionable. Because in defining something, we use its attributes (a bird can fly, or the sky is blue), but inverting the object and attribute, taking flying as primary, a bird is one of the things that adhere to the capability of flying. As I discussed, it is the tension between nouns and verbs. In the positivist tradition, we learn by sensory relations only. The dialectical aspects are completely squared away (like a real amplitude is squared away into a probability). In a Rovellian flash event, we speak more of a resonance than a sensation. We must have our notion of a stomach before we can understand the pain we feel in our belly after eating a toxic mushroom. Rovelli's fascination with Buddhism, in particular Nāgārjuna; "Reality, including ourselves, is nothing but a thin and fragile veil, beyond which . . . there is nothing" (Rovelli 2022a) is much closer to the later David Bohm's holistic interest in eastern philosophy, but then in a more idealist vein, than Rovelli suggests.

99 . "All the sciences will be guided by a universally wide science -not one that is hypothetical, debatable, and vacilliating like philosophy, but a science that is *exact* and thoroughly *emperical"* (Bogdanov 2026, 244).

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I wholeheartedly thank my friends Jan Visser, Herman Pieterson, Jarek Ervin, and Siyaves Azeri for their critical comments on (parts of) earlier versions of this paper.

Editorial comment.

The section 'studies' in our journal Marxism & Sciences, is meant to explore open questions and invites for comments and discussion. Consequently, we contacted Carlo Rovelli and invited him to react on this study. Unfortunately, clearly overloaded with work, he replied with: *Thanks, I have read it rapidly. It is very interesting and has rich ideas. I may find some time to study it in detail and maybe write a response. Although I tend to agree with what he says, and, at most, all I could do is to try to correct some small misreading of what I am trying to do...*
The discussion will go on.

Appendix

The question of what is leading, the experiments or the theory, is expanded in this paper to the understanding that a theory, as well as experimental results, are captured in language. If we feel or see something, we communicate this with common words, typical for the social-economic state of the art. At the other end of knowing, a theory explains to us the why and how, which is again based on common words. But a theory and particular one framed in mathematical language, has strict borders. Hence, we have an inclination for reducing the avalanche of sensory perception into a formal, well-defined model, which, if it works, can forecast not yet experienced sensory perceptions. However, this reduction limits its usefulness and forecasting capabilities only within the intrinsic limits of the theory.

This tension is well addressed in Heisenberg's recollection of an early conversation with Einstein. Which is partly quoted below. (Heisenberg 1972, chapter 5 'Quantum Mechanics and a Talk with Einstein (1925—1926) pp. 60–68).

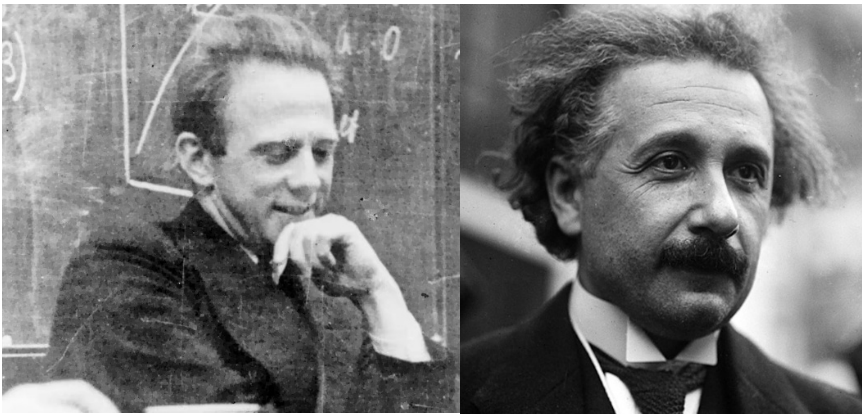

Figure 2. Heisenberg 1927; Einstein ~ 1923

“Toward the end of May 1925, I fell so ill with hay fever that I had to ask Born for fourteen days’ leave of absence. I made straight for Heligoland, where I hoped to recover quickly in the bracing sea air, far from blossoms and meadows.

In the spring of 1926, I was invited to address this distinguished body [the physics colloquium of the University of Berlin -JK] on the new quantum mechanics, and since this was my first chance to meet so many famous men, …I apparently managed to arouse Einstein’s interest, for he invited me to walk home with him so that we might discuss the new ideas at greater length. On the way, he asked about my studies and previous research. As soon as we were indoors, he opened the conversation with a question that bore on the philosophical background of my recent work. “What you have told us sounds extremely strange. You assume the existence of electrons inside the atom, and you are probably quite right to do so. But you refuse to consider their orbits, even though we can observe electron tracks in a cloud chamber. I should very much like to hear more about your reasons for making such strange assumptions.” “We cannot observe electron orbits inside the atom,” I must have replied, “but the radiation which an atom emits during discharges enables us to deduce the frequencies and corresponding amplitudes of its electrons. After all, even in the older physics wave numbers and amplitudes could be considered substitutes for electron orbits. Now, since a good theory must be based on directly observable magnitudes, I thought it more fitting to restrict myself to these, treating them, as it were, as representatives of the electron orbits.” “But you don’ t seriously believe,” Einstein protested, “that none but observable magnitudes must go into a physical theory?” “Isn‘t that precisely what you have done with relativity?” I asked in some surprise. “After all, you did stress the fact that it is impermissible to speak of absolute time, simply because absolute time cannot be observed; that only clock readings, be it in the moving reference system or the system at rest, are relevant to the determination of time." "Possibly I did use this kind of reasoning," Einstein admitted, "but it is nonsense all the same. Perhaps I could put it more diplomatically by saying that it may be heuristically useful to keep in mind what one has actually observed. But on principle, it is quite wrong to try founding a theory on observable magnitudes alone. In reality the very opposite happens. It is the theory which decides what we can observe [emphasises by JK]. You must appreciate that observation is a very complicated process. The phenomenon under observation produces certain events in our measuring apparatus. As a result, further processes take place in the apparatus, which eventually and by complicated paths produce sense impressions and help us to fix the effects in our consciousness. Along this whole path-from the phenomenon to its fixation in our consciousness-we must be able to tell how nature functions, must know the natural laws at least in practical terms, before we can claim to have observed anything at all. Only theory, that is, knowledge of natural laws, enables us to deduce the underlying phenomena from our sense impressions. When we claim that we can observe something new, we ought really to be saying that, although we are about to formulate new natural laws that do not agree with the old ones, we nevertheless assume that the existing laws-covering the whole path from the phenomenon to our consciousness-function in such a way that we can rely upon them and hence speak of 'observations.' "In the theory of relativity, for instance, we presuppose that, even in the moving reference system, the light rays traveling from the clock to the observer's eye behave more or less as we have always expected them to behave. And in your theory, you quite obviously assume that the whole mechanism of light transmission from the vibrating atom to the spectroscope or to the eye works just as one has always supposed it does, that is, essentially according to Maxwell's laws. If that were no longer the case, you could not possibly observe any of the magnitudes you call observable. Your claim that you are introducing none but observable magnitudes is therefore an assumption about a property of the theory that you are trying to formulate. You are, in fact, assuming that your theory does not clash with the old description of radiation phenomena in the essential points. You may well be right, of course, but you cannot be certain." I was completely taken aback by Einstein's attitude, though I found his · arguments convincing. Hence I said: "The idea that a good theory is no more than a condensation of observations in accordance with the principle of thought economy surely goes back to Mach, and it has, in fact, been said that your relativity theory makes decisive use of Machian concepts. But what you have just told me seems to indicate the very opposite. What am I to make of all this, or rather what do you yourself think about it?" "It's a very long story, but we can go into it if you like. Mach's concept of though t economy probably contains part of the truth, but strikes me as being just a bit too trivial. Let me first of all produce a few arguments in its favor. We obviously grasp the world by way of our senses. Even when small children learn to speak and to think, they do so by recognizing" the possibility of describing highly complicated but somehow related sense impressions with a single word, for instance, the word 'ball.' They learn it from adults and get the satisfaction that they can make themselves understood. In other words, we may argue that the formation of the word, and hence of the concept, 'ball' is a kind of though t economy enabling the child to combine very complicated sense impressions in a simple way. Here Mach does not even enter into the question which mental or physical predispositions must be satisfied in man-or the small child before the process of communication can be initiated. With animals, this process works considerably less effectively, as everyone knows, but we shan't talk about that now. Now Mach also thinks that the formation of scientific theories, however complex, takes place in a similar way. We try to order the phenomena, to reduce them to a simple form, until we can describe what may be a large number of them with the aid of a few simple concepts. "All this sounds very reasonable, but we must nevertheless ask ourselves in what sense the principle of mental economy is being applied here. Are we thinking of psychological or of logical economy, or, again, are we dealing with the subjective or the objective side of the phenomena? When the child forms the concept 'ball,' does he introduce a purely psychological simplification in that he combines complicated sense impressions by means of this concept, or does this ball really exist? Mach would probably answer that the two statements express one and the same fact. But he would be quite wrong to do so. To begin with, the assertion 'The ball really exists' also contains a number of statements about possible sense impressions that may occur in the future. Now future possibilities and expectations make up a very important part of our reality, and must not be simply forgotten. Moreover, we ought to remember that inferring concepts and things from sense impressions is one of the basic presuppositions of all our thought. Hence, if we wanted to speak of nothing but sense impressions, we should have to rid ourselves of our language and thought. In other words, Mach rather neglects the fact that the world really exists, that our sense impressions are based on something objective. "I have no wish to appear as an advocate of a naive form of realism; I know that these are very difficult questions, but then I consider Mach's concept of observation also much too naive. He pretends that we know perfectly well what the word 'observe' means, and thinks this exempts him from having to discriminate between 'objective' and 'subjective' phenomena. No wonder his principle has so suspiciously commercial a name: 'thought economy.' His idea of simplicity is much too subjective for me. In reality, the simplicity of natural laws is an objective fact as well and the correct conceptual scheme must balance the subjective side of this simplicity with the objective. But that is a very difficult task. Let us rather return to your lecture. "I have a strong suspicion that, precisely because of the problems we have just been discussing, your theory will one day get you i n to hot water. I should like to explain this in greater detail. When it comes to observation, you behave as if everything can be left as it was, that is, as if you could use the old descriptive language. In that case, however, you will also have to say: in a cloud chamber we can observe the path of the electrons. At the same time, you claim that there are no electron paths inside the atom. This is obvious nonsense, for you cannot possibly get rid of the path simply by restricting the space in which the electron moves."

For the time being, we have no idea in what language we must speak about processes inside the atom.

> Hence I cannot really claim that we have 'understood' quantum mechanics. I assume that the mathematical scheme works, but no link with the traditional language has been established so far. And until that has been done, we cannot hope to speak of the path of the electron in the cloud chamber without inner contradictions. Hence it is probably much too early to solve the difficulties you have mentioned." "Very well, I will accept that," Einstein said. "We shall talk about it again in a few years' time.
>
> Einstein warned me. "For you are suddenly speaking of what we know about nature and no longer about what nature really does. In science we ought to be concerned solely with what nature does. It might very well be that you and I know quite different things about nature. But who would be interested in that? Perhaps you and I alone. To everyone else it is a matter of complete indifference. In other words, if your theory is right, you will have to tell me sooner or later what the atom does when it passes from one stationary state to the next- " "Perhaps, " I may have answered. "But it seems to me that you are using language a little too strictly. Still, I do admit that everything that I might now say may sound like a cheap excuse. So let's wait and see how atomic theory develops." Einstein gave me a skeptical look. "How can you really have so much faith in your theory when so many crucial problems remain completely unsolved?" etc. (Heisenberg 1972, chapter 5 'Quantum Mechanics and a Talk with Einstein (1925—1926) pp. 60–68.

After a century, these problems are not yet solved, though rephrased in highly mathematical quantum field theory: hence pragmatically solved. As explained in the study, we are mathematically forced to interpret the square of the amplitude in the wave picture as a probability (the so-called Born rule). As a consequence, presently the probabilistic nature of quantum mechanics rules the waves. However, the why a transition between stable atomic states happen is still unanswered. Alternative theories are Bohm's causal interpretation (Bohm 2025) and some versions of so-called super-deterministic theories are challenging the accepted interpretation. As long as quantum mechanics works, few people care about it and in education the problem is absent. Actual theories that try to merge gravity theory and quantum mechanics, such as string theory and loop gravity have not yet produced any tangible results. The unknown only growth!

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