Wittgenstein, Modern Physics and Zeilinger‘s Pronouncement, or How Naive Was Wittgenstein? (Revised and updated)

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Abstract

This paper examines the almost ineradicable misconception of Wittgenstein's alleged antagonism to science as evidenced through some characteristic disparaging comments by world-renowned scientists, notably by Anton Zeilinger. Above all, he criticizes Wittgenstein on the basis of the opening sentence of the *Tractatus Logico-Philosophicus*, "The world is all that is the case", which he regards as expressing *"the naive world-view"* of a *"typical philosopher of classical physics"*.[1] He proposes an extension in agreement with the findings of quantum theory, namely by the clause *"… and all that can be the case"* (Zeilinger 2003, 231).

It will become apparent, however, that this amplification is redundant, that Wittgenstein was in tune with modern physics, that a surprising number of his philosophical concepts are in agreement with it, and that various quantum pundits consider them to be relevant.

Keywords: Wittgenstein, Tractatus , science versus philosophy, relativity theory, quantum physics, Zeilinger

> "[Wittgenstein] has often been accused of engaging in a priori armchair science, but would respond that it is scientistic philosophers who engage in an incoherent discipline – empirical metaphysics." (Glock 2005, 295 f.)

1. Why Wittgenstein? Why Zeilinger?

In the recent past, a number of scientists have chided philosophy, notably contemporary philosophy, for its inefficiency and irrelevancy, thus triggering a series of lively debates in which most of their criticisms were refuted, and often brilliantly so.[2]

In this context, a mere glance at the Anglosphere will bring to mind at least three luminaries singling out Wittgenstein to illustrate their assaults on philosophy: Stephen Hawking, Steven Weinberg, and Lawrence Krauss.

In his "Brief History of Time" (Hawking 1988, 191) Hawking proclaims: "[…] in the nineteenth and twentieth centuries, science became too technical and mathematical for the philosophers, or anyone else except a few specialists. Philosophers reduced the scope of their inquiries so much that Wittgenstein, the most famous philosopher of this century, said, 'The sole remaining task for philosophy is the analysis of language.' What a comedown from the great tradition of philosophy from Aristotle to Kant!" This, however, is an oversimplification. Glock concedes that "[t]his picture seems to impoverish philosophy, and is generally considered to be the weakest part of Wittgenstein's later work […]". But these are "slogans unsupported by argument […]. Wittgenstein's methodological views must ultimately be judged by their results" (Glock 2005, 294 f.) - which have been manifold and far-reaching.

In response, one could point out to Hawking that even in the quantum realm Wittgenstein's philosophy can be put to considerable use – see, e.g., the four examples in Section 8 of this paper.

Or one could answer Hawking's reproach by means of a comparison with the German academics of the Weimar epoch, the heroic age of quantum physics: "Culturally, a truly great scientist was expected not only to make discoveries in a special field of research, but […] to contribute a general philosophical outlook […], transcending narrow professionalism and disciplinary boundaries." (Kojevnikov 2011, 344) The ideal was the comprehensively educated *Universalgelehrte*. What a comedown since then!

(In "The Grand Design" (2010, 5) Hawking famously even raises the stakes: "[…] philosophy is dead. Philosophy has not kept up with modern developments in science, particularly physics" – this time, however, without making reference to Wittgenstein.)

Referring to *Tractatus* 6.371, Steven Weinberg (1994, 28f.), in utter dismissal of Wittgenstein's (and not only his!) thinking, has this to say: "Ludwig Wittgenstein, denying even the possibility of explaining any fact on the basis of any other fact, warned that 'at the basis of the whole modern view of the world lies the illusion that the so-called laws of nat. are the explanations of natural phenomena' […]. Such warnings leave me cold." To which Wittgenstein – through Schlick ("I owe this idea and terminology to Ludwig Wittgenstein.") – might, e.g., answer: "[A]t bottom a law of nature does not even have the logical character of an 'assertion', but represents, rather, 'a prescription for the making of assertions' " (Schlick 1979, 188); or, with

John A.Wheeler's idea "that physical laws could not appear in a truly fundamental description of nature […] - [h]ence the expression 'law without law' ". (Deutsch 1986, 565)

Also Lawrence Krauss, cosmologist and popular-science writer, generated a controversy by making some disparaging remarks about philosophy in "A Universe From Nothing: Why There Is Something Rather than Nothing" (2012). Under pressure during a subsequent interview by his interlocutor's statement that "computer science […] was to a large degree built on foundational work done by philosophers in logic and other formal languages" (Anderson 2012), he tried to relativize his judgements, for instance by claiming that Wittgenstein did not really do philosophy at all and that his pioneering work in the *Tractatus* had no influence on the development of informatics: "In the case of descriptive philosophy you have literature or logic, which in my view is really mathematics, and there are philosophers like Wittgenstein that are very mathematical, but what they're really doing is mathematics – it's not talking about things that have affected computer science, it's mathematical logic."

This is not the place to rehash these debates. But the question arises to what factors Wittgenstein owes the unsolicited honour of representing 20th century philosophy in suchlike debates, particularly among the philosophically underinformed. It may safely be assumed that the reason cannot be found in the involved scientists' penetrating analyses and their deep knowledge of his works. Can it be found in a desire for self-aggrandizement by claiming intellectual superiority over the "most famous philosopher" (Hawking, see above) of the 20th century? Or is it simply a result of his lasting or even proliferating iconic status in art, music, and literature (which is probably also due to external factors such as family background, biography, eccentricity, charisma)? Or is it that a blow to him, the alleged "archfiend of science", will at the same time discredit the whole field of activity from which, after all, his "antagonism" purportedly sprang? Be that as it may, this paper will focus on two pronouncements on Wittgenstein by Anton Zeilinger.

Zeilinger – and his motives? – seem to differ fundamentally from the aforementioned: He has repeatedly published (e.g., "On the Interpretation and Philosophical Foundation of Quantum Mechanics", 1996) and been interviewed on the philosophical implications of his work, saying, e.g.: "I have a program where I invite philosophers to see what goes on in the lab" (Powell 2011). He regards philosophy as very significant for bringing together diverse strains of thought and areas of life, and he expressly regrets the fact *"that the philosophical aspects of the natural sciences have fallen behind by the shift of the natural sciences to the USA"*. (Zeilinger 2002).

And yet he excoriates the philosophy of Ludwig Wittgenstein. Why?

"Ludwig Wittgenstein is a quantum (manifold) thinker."
(Blum 2006, 176)

"The idea that the world is composed of facts, not of things, was formulated in philosophy before quantum mechanics. Namely, in 1918 Ludwig Wittgenstein wrote his famous theses: '1 The world is all that is the case. 1.1 The world is the totality of facts, not of things.' "
(Ingarden 2000, 36)

2. Evolution of a prejudice

There is no denying that attitudes like those described in Section 1 were fostered and cherished well into the 2000s, even in professional publications on philosophy, despite Wittgenstein's pervasive background in engineering and in flagrant disregard of all the information meanwhile available:

"[…] if he had taken an interest in the monumental struggles taking place in contemporary science over quantum physics […]" (MacFarlane 2001)

"Obviously he did not know modern physics!" (Fröhlich 2007, 98)

"[H]e did not know modern science." (Stenholm 2011, 5)

"Wittgenstein does not seem to have been impressed by relativity theory and the beginnings of quantum mechanics […]." (Baltas 2012, 254)

This permeant preconception – which neglects the fact that he "had studied science and engineering and appreciated the rigor and sharpness of the scientific way of thinking" (Kindi 2017, 589) – is certainly a consequence of Wittgenstein's methodical criticism of "the ideological use of science, of the pretensions of scientists to offer authoritative judgments on all kinds of issues and of reducing any problem to a scientific one." (ibid., 589) Moreover, some of his own statements were prone to mis- or overinterpretation, e.g.:

"I may find scientific questions interesting, but they never really grip me. Only conceptual and aesthetic questions do that. At bottom I am indifferent to the solution of scientific problems; but not of the other sort." (CV 1980, 79)

Kuusela justly states that "the record for Wittgenstein's views on science should be corrected".[3] But in Glock/Hyman's "A Companion to Wittgenstein" (2017), the "most comprehensive survey of Wittgenstein's thought yet compiled" (Wiley-Blackwell's advertising slogan), his position concerning 20th century physics is not a topic. Even admirers of Wittgenstein, such as Ray Monk, his foremost biographer, have their share of disseminating the kind of misconceptions quoted above: In his classic, "The

Duty of Genius", he hardly mentions science or scientists, even if they played a substantial role in Wittgenstein's life – with the exception of Boltzmann (p. 26 = once!) and Hertz (pp. 26 & 446 = twice!). Moritz Schlick, philosophical propagator of the theory of relativity and proficient commentator on the developments in quantum theory, is presented as "Professor of Philosophy at the Vienna University" (Monk 1991, 241), when actually he occupied the chair of "Naturphilosophie", previously held by Mach and Boltzmann (specially created for Mach as "Chair for the Philosophy of the Inductive Sciences"). There is only one entry on the topic of science in the index, namely "science: L.W.'s antagonism to" (Monk 1991, 652), which, however, in all cases refers to Wittgenstein's attacks on scientism, not on science! (Nordmann, by contrast, in an attempt to solve the conundrum of how Wittgenstein became a philosopher rather than an engineer, audaciously "inverts the perspective" (Nordmann 2002, 357) and suggests: "Perhaps, Wittgenstein never became a philosopher but was always a scientist or engineer.")

And then, of course, there are Wittgenstein's opponents, notably his detractor Ernest Gellner, who railed against everything Wittgensteinian, and above all against "his rejection of the positivist idea that philosophy is essentially linked to science […], i.e., either as substantially continuous with it […] or methodologically as Russell and the Vienna Circle believed." (Janik 2001, 148) Although "[t]he view that the later Wittgenstein is fundamentally anti-scientific turns out to be profoundly inaccurate" (Janik 2001, 148), Gellner "[i]n effect […] views Wittgenstein as hostile to the scientific world-view" (Skalnik 2003, 218). As a consequence, "[d]espite major alterations in our picture of Wittgenstein in the intervening years a shocking number of philosophers (and others) have retained Gellner‘s image to this day." (Janik 2001, 148) Neither clarifying statements by distinguished experts such as Rupert Read ("Wittgenstein has been widely misunderstood as hostile to science. What Wittgenstein was in fact hostile to is only scientism." Read 2012, 185) nor attempts to rehabilitate Wittgenstein by presenting "resources for countering the still prevalent view that he [was] disconnected from the progress of serious science" (Stenlund 2015, Abstract) have been sufficiently apprehended yet. Rather, this misconception is still gaining ground, stimulated by various allegations of prominent scientists – which is to be illustrated by means of the case study announced above.

3. Zeilinger's pronouncement

Zeilinger's bestselling popular-science introduction to quantum physics, "Einsteins Schleier. Die neue Welt der Quantenphysik" (2003),[4] culminates in a pointed Parthian shot at a defenceless last-page newcomer to the treatise:

*"Wittgenstein opens his famous *Tractatus Logico-Philosophicus* with the sentence:

'1.1 The world is all that is the case.'[5]

We have seen that this viewpoint is too narrow.[6] In quantum physics we cannot only make statements on what *is* the case but also statements on what *can* be the case. […] But these predictions about the future are statements about everything that *could* be the case. Needless to say, these statements are also part of the world.
Therefore, the world is more than what Wittgenstein thought. *The world is all that is the case, and all that can be the case."** [Zeilinger's italics] (Zeilinger 2003, 231)

On Nov. 9, 2011, in the Austrian daily *Der Standard*, Zeilinger's lecture at a symposium hosted by the Austrian Academy of Sciences on occasion of the 60th anniversary of Wittgenstein's death was summarized as follows:

> *"Naive world-view
>
> Wittgenstein's explanation of the world in the very first sentence of the 'Tractatus' ('The world is all that is the case') was critically viewed by the experimental physicist, Anton Zeilinger, already in his book 'Einsteins Schleier'. Zeilinger calls it a 'naive world-view' of a 'typical philosopher of classical physics'. In the light of quantum physics, with which Wittgenstein never occupied himself, Zeilinger proposed a revision of this sentence: 'The world is all that is the case and all that can be the case.' (APA)"*[7]

A look on the internet will show that both the less polished precursor versions of this sentence and the pithy final one have been well received among quantum physicists but never directly challenged.[8] Ironically, however, at least two physicist-philosophers – both of them critical of Zeilinger's quantum philosophy – have perceived some unintended similarities between Zeilinger's postulates of his "foundational principle for quantum mechanics" (Zeilinger 1999b) and some Tractarian notions, namely Timpson (see below, Annotation 13) and Jaeger, who especially points to (the unaltered!) propositions 1 and 1.1 in connection with Zeilinger's elucidations, which thus inadvertently confirm the basic suitability of some aspects of the *Tractatus* for quantum theoretical deliberations (see also Section 8 of this paper):
"An obvious way of approaching this picture [Author's note: i.e., Zeilinger's position] is to compare it with the ideas of the early Wittgenstein, in which 'the world is everything that is the case' and 'the totality of facts, not of things.' " (Jaeger 2009, 236)

So it seems, then, that Wittgenstein's influence on the thinking of modern physics – substantial in the opinion of experts, though perhaps negligible in the eyes of sceptics

– is, in the last analysis, at least strong enough for a subliminal impact even on his critics.

In the next two sections, Zeilinger's claim will be subjected to further critical scrutiny on the basis of the *Tractatus* and of Wittgenstein's biography.

> Topics will cover his early years in Boltzmann's Vienna, then his study in Planck's (and then Einstein's) Berlin, then his move to Rutherford's Manchester and eventually his arrival to join the cohort of great physicists in Cambridge in the 1930s and 1940s.“
> (Preview HAPP-Conference „Wittgenstein and Physics“, Oxford 2014)

4. Wittgenstein and Einstein

In his autobiography, "Ex-Prodigy, My Childhood and Youth", N. Wiener reminisces about how Russell was one of the first philosophers to understand the significance of Einstein's work, and how he was introduced to relativity theory in a course of Russell in 1913 (Wiener 1953, 191, 200). And in 1914 and 1915, Russell kept "referring to the theory of relativity (OKEW 89, RSDP 159, and SMP 114) and to the principle of relativity (OKEW 104 & 242, and UCM 135)". (Desmot 2010, 195) This is, of course, merely circumstantial evidence, but it would certainly be preposterous to think that Russell and Wittgenstein, in all of their intense discussions between 1911 and the beginning of the First World War, should have completely shunned the topic of relativity.

For the years after the First World War, however, beginning with November 1919 – "Wittgenstein must certainly have been impressed by the confirmation of Einstein's Relativity Theory […]: most newspapers in Europe had front-page headlines" (Penco 2010, 2 resp. 361) – Penco marshals detailed evidence: analogies between relativity theory and Wittgenstein's philosophy, plus historical and, above all, robust textual documentation!

By all accounts, Wittgenstein was a very intense listener (Schulte, 1989, 11, footnote 4), and in his environment in Vienna and Cambridge "many people were discussing Relativity Theory, particularly his friends, from Schlick to Russell" (Penco 2010, 2). The Einstein-Schlick correspondence shows how highly Einstein valued Schlick‘s interpretations of his theory. Penco concludes that "there was a profound connection between Wittgenstein and relativity theory" (Penco 2010, Abstract). To support his claim that Wittgenstein took special care to show that he was "in tune with Relativity Theory" (Penco 2010, 1 resp. 360), he looks at an "abundance of citation" in the *Nachlass*, "repeated many times between 1929 and 1950" (Penco 2010, 4):

"In the *Nachlass* there are numerous 'robust' sentences (sentences that are repeated in different contexts at different times), which also applies to "the subject of Einstein and Relativity Theory[…]:
Mainly from '29 until '33:
[Author's note: In the following examples, only the English translations will be cited.]
(1) […] (In the 'not being able to go beyond themselves' we find the similarity between my observations and those of Relativity Theory) [Ms 108 p.270-71, Ms 210, p.70; Ms 212, p.985, TS 212: 985; Big Typescript: § 76, p.356].
(2) […] ('Einstein: how a magnitude is measured is what it is') [Ms 107, p.143: Ms 113, p.142; Ms 130, p.241; […].
From '41 onwards:
(3) […] (This is the similarity of my treatment with relativity theory, that is, so to speak, a consideration about the clocks with which we compare events) [Ms 164: 82; RFM VI: §28; cfr. UG: 303-305]" (Penco 2010, 3 f.)

In a comment on quotation (1) above, he points out that the beginnings of an evolving connection between relativity theory and Wittgenstein's thinking may be discernible already in the *Tractatus*: "Actually this remark seems apparently linked to the main ideas of the *Tractatus*, with its anti-metalinguistic attitude. […] it helps to show our philosopher continuously re-shaping his interpretation of the connection between Einstein and his evolving ideas […]. It seems that Wittgenstein, fascinated by the most significant discovery of the century, tries to stay in touch with it while developing his own ideas." (Penco 2010, 11 f.)

In a similar vein, Kusch (2011) compares some of Einstein's and Wittgenstein's views in and after the late 1920s, with a focus on clock-coordination and metrology, in order to gain new interpretational perspectives and additional insights into some of Wittgenstein's central ideas and themes, notably with regard to *On Certainty* and to his considerations on rule-following.

In the face of such impressive evidence on the topic of Relativity it becomes irrefutably clear that Wittgenstein, even if he had ignored quantum theory, can definitely no longer be disparaged as a "naive philosopher of classical physics".

*"It can't be possible –"
"Actuality is always the finest proof of possibility."*
Johann Nepomuk Nestroy, *Der Talisman/*The Talisman**,
Act Three/Scene 18

5. Wittgenstein and quantum physics: the (pre-)Tractarian years

There are, as already indicated (see above, Section 3), certain affinities between quantum physics and the *Tractatus*, which will come as a surprise to many. In this context two caveats must, however, be heeded: In his physical description of the world, Wittgenstein did not aim to extol "die aktuell bessere Theorie" (Kokai 2005), i.e., the currently better theory, but to bring out the "network character" of physical theories; and the world of the *Tractatus* must by no means be equated with the world of physics, which solely concerns the universe, i.e., a mere "ontological province" (Gabriel 2013, 51). The *Tractatus*, by contrast, deals with *"a constellation of Fragestellungen*" (Brock 2016, 189), i.e., with a whole range of very diverse spheres such as "[m]etaphysics, logic, sentence, truth operations, mathematics, natural science, non-sense shown, ethical, mystical, human life" (ibid., 190). His "world" is more than physics: It is to be imagined as *"logical form, but not as a realm of mere ideas, untouched by everything material"* (Goppelsröder 2007, 19).

For Wittgenstein's years in Einstein's Berlin and in Rutherford's Manchester, no indication could be found that he occupied himself with quantum physics. In 1912, just a few months after his arrival in Cambridge in October 1911, he began his work on the *Logisch-Philosophische Abhandlung*. The situation of modern physics was much better there than in Vienna, at whose university the chairman of the Institute of Physics, Ernst Lecher, rejected the first quantum mechanical atomic model (by Arthur Haas) as a *"carnival joke"* (Flamm 2001), whereas Cambridge was already a centre of theoretical work on the structure of atoms and molecules, and therefore Niels Bohr chose it as his sojourn for about half a year, from September 1911 to March 1912. In that year, the quantum issue was still unresolved and declared by Einstein to be the central problem of physics. "Quantum theory as we know it began with Bohr's formulation around 1913" (McCrea 1985) – in Manchester, which Wittgenstein had left in 1911. But in order to avoid an ahistorical perspective, it should be kept in mind that the "Tractatus was written in the days of the old Quantum Theory. The new Quantum Theory, with its challenge to Newtonian Mechanics had not yet arrived" (Young 2004, 130), and that *"in their time of origin, the revolutionary theories that shaped the new conception of the world in the 1920s, the theory of relativity and quantum theory, were rather part of a consolidation programme […] on a higher level of reflection"* (Heidelberger 2002, 84), i.e., initially these developments in physics were seen as a process, not as a revolution. [9] So it would almost constitute an anachronism to demand a deep knowledge of (the early) quantum theories from a

Viennese philosopher of that time. And yet, already in the *Tractatus* there are some, as it were, quantum physical trains of thought, apparently developed in accordance with Boltzmann's thinking: "With the new emphasis on statistical explanation characteristic of quantum mechanics, the importance of Boltzmann's method has only increased. In particular, his method of specifying the physical state of a system, by reference to a multi-dimensional space whose coordinates represent all the independent variables of the system, has been taken over entirely into the standard presentations of modern quantum theory." (Janik 1973, 144) Boltzmann's "space of theoretical possibilities", which played the key role in "Boltzmann's statistical method of analysis" (ibid.), corresponds perfectly to paragraphs 1.13, 1.2, 1.21, 2.1, 2.201, 3.4, 3.411 of the *Tractatus*. "It was no accident that Wittgenstein's *Tractatus* was required reading in Schlick's Vienna Circle of philosophically minded scientists and scientifically minded philosophers." (Yourgrau 2006, 39)

6. Quantum theory and Wittgenstein's philosophy: further affinities

There are some remarkable studies on the value of Wittgenstein's philosophy of language – "Every question, whether concerning philosophy or science, is expressed in a language. Every answer, even when based upon experiment, must use logic." (Omnès 1994, 520) – for the description of quantum physics, and some (see especially Omnès 1995, 1ff.) that juxtapose Wittgenstein's concepts with complementary views of Bohr and Heisenberg. Not all of them start from valid premises, not even Stenholm's basically profound comparison between Bohr and Wittgenstein: "It is argued that many of the features of Wittgenstein's later work could have been applied to quantum physics, if only he had known about this", but alas, "he did not know modern science" (Stenholm 2011, 5) – which is wrong (see, e.g., MS 105 as quoted in Section 7 of the paper in hand). So, Stenholm's starting point is his firm belief that Wittgenstein was a philosopher of classical physics, and he looks at his work under this preconception, resulting in a vicious hermeneutic circle. For instance, his method of approaching the *Tractatus* is "to paraphrase this work so that it can be directly applied to such an interpretation" (Stenholm 2011, 183). In the chapter "Wittgenstein and physics" (ibid., 189 ff.), he presents "relevant statements from several of his published books", on the basis of which "[r]elations to modern physics are pointed out […]". It would be interesting to know what conclusions he would have drawn without the all-pervading bias that any correlations whatsoever must needs be purely coincidental.[10]

In the following, Stenholm's concept will be challenged by several examples that point to the contrary: three approving interpretations of Wittgenstein's thought in this section (to begin with, by means of a fresh glance at the history of early quantum theory), and then a look at circumstantial and archival evidence in Section 7.

For Steen Brock, the new era of physics begins with Helmholtz, Hertz, and Boltzmann:
„I explain in my thesis [*Niels Bohr's Philosophy of Quantum Physics in the Light of the Helmholtzian Tradition of Theoretical Physics, 2003*], both relativity theory and early quantum theory made use of The Principle of Least Action [6.3211] in order to regulate the possible set of phase-spaces (logical spaces) available in the formation of a new theory. […] the author of the TLP did not view physics with 'classical eyes'. […] The TLP was indeed a radical work almost preceding what actually happened.“[11]

Bezerra furnishes examples of "concepts shared by *Tractatus* and quantum mechanics" (2015, 26 ff.) by juxtaposing quotations from Bohr, Dirac, Pauli, Feynman, and Schrödinger on possibility, probability, the exclusion principle, quantum entanglement, the uncertainty principle, the structure of the "quantum world", and the Schrödinger equation with sentences from the *Tractatus*. By means of these affinities he manages to reveal an intellectual and philosophical "entanglement" between the *Tractatus* and quantum physics. For him, this is not an "amazing coincidence", but due to the impact of the prevailing Zeitgeist plus Wittgenstein's intellectual alertness and brilliance, i.e., to the fact that "Wittgenstein saw things that his colleagues didn't see."[12] (In "Was der Fall ist, der Tractatus", 2014, he pays tribute to his pioneering achievements in informatics, which is also Zemanek's (cf. Zemanek 1993, abridged version 1 f.) viewpoint.)

A third treatise – again with a different modus operandi – will take us right back to this paper's point of departure, i.e., to "Einsteins Schleier". As neither Zeilinger's book nor its analysis in Czasny's work on the epistemology of physics are available in English, it will be necessary to first deal with those passages which finally lead to Zeilinger's new version of *Tractatus* 1, and to subsequently follow Czasny's train of thought which results in his refutation of Zeilinger's reformulation**.**

In the last chapter, after a highly accomplished introduction into quantum physics, Zeilinger – like other seekers of a foundational conceptual principle for quantum mechanics before him – moves on to quantum information and from there to a metaphysics of "informational immaterialism" (Timpson 2013, 1).[13] His cogitations head for two pivotal statements about "reality", i.e., the (quantized) "world", and about (quantized) "information" (Zeilinger 2003, 225 f.): his *"radical suggestion"* that "Wirklichkeit und Information sind dasselbe" (*"Reality and information are the same"*), and – as a consequence – his new version of *Tractatus 1*. However, the chain of arguments leading to these verdicts is somewhat problematic: firstly, because of the inconsistent exegeses of the term "information" and its factual equalization with "reality" (*"This is a hypothesis which […] will hardly bear philosophical analysis"* – Pirner 2003, 11), and secondly, because of the fuzzy use of the word

"Wirklichkeit" (*"whatever that may be"* – Zeilinger 2003, 213), under which he unfortunately subsumes both reality and actuality. A more precise terminology would certainly have been advantageous in this context: "[…] in the quantum domain […] Leibniz' and Kant's distinction of reality and actuality is helpful." (Falkenburg 2007, 20)

Czasny, for his part – he actually praises "Einsteins Schleier" as *"extremely stimulating"* (Czasny 2014, 8) – provides an astute analysis of the epistemological problems, argumentation patterns, and reflection deficits of quantum physics in general, and then proceeds to specify his elucidations by means of this book – a circumstance highly conducive to this paper. To begin with, he points to Zeilinger's indecisiveness between *"a materialism in the shape of an ontology of information and its subjectivist antithesis, a constructivism of information"* (Czasny 2014, 14), then analyzes the two terms "reality" and "actuality", and comes to the conclusion that reality is the more comprehensive term, as it contains both what is real or just possible for us, plus "those aspects of the object which are beyond our information of it and our interaction with it" (Czasny 2014, 29). Zeilinger's reformulation of *Tractatus* 1 shows *"that Zeilinger fades out the very two aspects that are so decisive for the subject-object relationship, thus reducing the world to the polarity between the subjectively actual**,** which is constituted by our observations and propositions on the one hand, and – on the other hand – that which is, in the light of our propositions, merely possible […]"* (Czasny 2014, 29, footnote 22). By means of the foregoing criticisms and the following deliberations and quotations he can demonstrate that Zeilinger's amendment to *Tractatus* 1 is redundant:

He first elucidates the depiction of the aspect of actuality (i.e., that which is the case) in the *Tractatus* by means of five sentences (1, 1.1, 2, 2.01, and 2.021) and then "the aspect of possibility, which (inter alia) is dealt with in the following three paragraphs":

2.0123 If I know an object I also know all its possible occurrences in states of affairs. (Everyone of these possibilities must be part of the nature of the object.) A new possibility cannot be discovered later.

2.0124 If all objects are given, then at the same time all *possible* states of affairs are also given.

2.014 Objects contain the possibility of all situations.

Czasny concludes:

> *"The objects, on the one hand, belong to the actual (= existing) world (and even constitute its substance), and on the other hand – by their very 'nature' – they also contain all possibilities of their occurrence; therefore, for the *Tractatus*, all possible worlds belong to the world just like the actual world itself."*[14]

This thought is expressed similarly by Goppelsröder (2007, 19): *"Beyond their character as coordinates in logical space, the objects constitute the 'substance of the world'"*, which is the reason why *"always one of many potentialities is actualized, while the others remain possible."*

7. Quantum theory and the later Wittgenstein

As of 1927, Wittgenstein exchanged ideas with Schlick not only in writing but face to face. *"Schlick probably began to study quantum physics in the mid-1910s"* (Schlick 2009, 394, editor's footnote 99). His *Allgemeine Erkenntnislehre* of 1918 included quantum physics, revised and enlarged in the second edition of 1925.

Wittgenstein's acquaintance with Dirac and Freeman Dyson in Cambridge remained inconsequential, but he made friends with the physicist W. H. Watson, "who attended some of Wittgenstein's classes and met with him privately occasionally in the academic years 1929-30 and 1930-1." (McGuinness 2012, 192) Their friendship and correspondence ("My Dear Watson", "My Dear Wittgenstein") endured for many years. Just to cite one example, from Watson's letter to Wittgenstein of 29.12.1932: "If I had had a copy I should like to have sent you Max Planck's lecture on 'The concept of causality' – it is recorded in the Proceedings of the Physical Society of London, September 1932: it is marvellously muddled." (McGuinness 2012, 206) Despite the ironical twist, the message is clear: Watson knows that this is a piece of information Wittgenstein will definitely appreciate.

The fact that Wittgenstein actually did reflect on quantum theory in those years becomes apparent in MS 105, 3f. (1929!) of the *Nachlass*: After some remarks and considerations on the grammar of phenomenology and about physics, he writes: *"Physics has a language, and in this language it says sentences. These sentences can be true or false. […] But this matter looks more difficult due to the use of the terminology of mathematics. If, e.g., science is in doubt whether the observed phenomena can be described correctly by means of the theory of electrons or by quantum theory, is seems at first glance as if it were a decision concerning grammar."* (Note: In such contexts, the German noun "Satz" can be translated as "sentence" or as "proposition", and therefore it can quite naturally collocate both with language and with physics.)

In 1938 Watson published his first great work, *On Understanding Physics*, "making much use of Wittgenstein's teaching" (McGuinness 2012, 192) and giving wide rein to quantum physics. It is hardly conceivable that Wittgenstein talked about quantum physics neither with Schlick (cf. Kusch 2014) nor with Watson: "So here in that book by Watson BOTH the TLP and Wittgenstein's later work is associated with a view on how quantum physics grew from an analogy with classical electrodynamics." (Brock)[15] This "indebtedness to Wittgenstein" (McGuinness, 2012, 192) still holds true for the second edition of 1963 (Understanding Physics Today, CUP).

Also in 1929, Wittgenstein became acquainted with Piero Sraffa, a brilliant Italian economist, who exercised a "profound influence on Wittgenstein's development. […] Wittgenstein would arrange to meet him at least once a week for discussions". (Monk 1991, 260) He was much interested in the implications of science for economics, but he was sceptical about the use of a Newtonian methodology. Therefore he took up quantum physics: "Sraffa read and annotated P. W. Bridgman's The Logic of Modern Physics (Bridgman, 1927) and referred to it in his papers." (Kurz and Salvadori, 2005, 85) "In May 1946 Piero Sraffa decided he no longer wished to have conversations with Wittgenstein […]. This came as a great blow to Wittgenstein." (Monk 1991, 487) Again it is hard to imagine that in the seventeen years of their close acquaintance they never talked about quantum physics. Or more broadly, "it would be very strange if he never considered if the development of both quantum physics and the theory of relativity did or did not challenge his gradually changing views on the relationship between symbolism and experimental science. Since the development of physics in both cases involved a recognition of the observational practices of the physical experimentators, Wittgenstein might well have thought that his later philosophy was somehow in line with this recognition." (Brock 2006, 71)

But there is more than just circumstantial evidence. It can now be absolutely verified that in the 1930s Wittgenstein was in tune with modern physics, namely by means of a part of the *Nachlass*, the recently discovered and evaluated so-called *Hidden Revision* (Wittgenstein's preparatory work for the *Philosophische Bemerkungen/ Philosophical Remarks*), as presented in a video recording of a high-calibre lecture by Edwards-McKie, 2014, where she elucidates – among others – Wittgenstein's concepts of time, space, infinity, indeterminacy, indeterminism, action-at-a-distance, infinite divisibility, etc., and "his precursor ideas to entanglement as an indeterminate system". She draws attention to his article "Some Remarks on Logical Form" (1929), which "sets the stage for the entanglement idea." After these "significant *Nachlass*-discoveries over the past two years" Wittgenstein must be regarded not only as a significant philosopher of language and mathematics but also of physics: "At a deep level – when viewed through the *Hidden Revision* – the *Philosophical Investigations* have far more to say about mathematics and physics than has hitherto been thought."

(Edwards-McKie, 2014) And then she announces: "[I]n a projected book [*Wittgensteinian approaches to the quantum level*] for Cambridge University Press, I argue for a reappraisal of Wittgenstein's philosophy of physics." (Edwards-McKie 2015, Abstract)

Mugur-Schächter, a theoretical physicist who aims to develop a transdisciplinary, general "formalized epistemology" with special regard to (and chiefly based on) quantum mechanics, is similarly enthused by a related aspect of "Some Remarks on Logical Form". Commenting on her "principle of individual spacetime mutual exclusion" ("P 10") (Mugur-Schächter 2002, 144), she states: "The quantum mechanical principle of 'complementarity' can be regarded as the realization of P10 for the particular category of physical object-entities consisting of states of microsystems. […] What is impossible indeed is only the simultaneous realization of two mutually incompatible quantum mechanical measurements upon *one* given replica of the considered microstate." (ibid., 145)

Later, progressing to "dual spacetime mutual exclusion" (ibid., 228 f., footnote 20), she remarks on Wittgenstein's discussion of the two colliding propositions "Brown now sits in this chair"and "Jones now sits in this chair" (Wittgenstein 2015 b, 169 ff.): "[…] this kind of dual spacetime mutual exclusion cannot be expressed by a *principle* like P 10. But it is very striking indeed that – without benefiting of guidance by quantum mechanics, which in the present work led toward 'the ultimate analysis of the phenomena in question' – Wittgenstein as early as 1929 identified the decisive individualizing role played by spacetime in the factual mutual exclusions of two propositions […]." (ibid., 229, footnote 20 ctd.)

In 1933 – at a time when he had already turned away from the *Tractatus* –, the second impression of the bilingual edition, with corrections by Wittgenstein, appeared. As is well known, he rejected it for a number of reasons – but not for any exasperating deficits in quantum theory, with which, as shown above, he was definitely familiar by that time.

> How else can one make sense of a Bayesian take on pure quantum states than to explore the same paths as Wittgenstein in his book *On Certainty*?
> (Christopher A. Fuchs, 2014, 812)

8. Wittgenstein's impact on current quantum theory

At least four modern approaches to quantum theory have utilized some of Wittgenstein's thoughts or been partly inspired by them:

R. Omnès, one of the main representatives of the consistent histories interpretation of quantum mechanics, sometimes advertising itself as "Copenhagen done right", repeatedly refers to Wittgenstein in "The Interpretation of Quantum Mechanics" with considerable appreciation. He summarizes at some length his "logical description of reality", as Wittgenstein's "approach is easily mimicked in the logical formulation of quantum mechanics. Wittgenstein's 'facts' are potential […]". He does so in order "to make sure that our own approach to reality and truth is significant from the standpoint of a valuable theory of knowledge". He points to the "existence in quantum mechanics of properties that cannot be 'facts' and cannot even be checked as being existent or not", which "also fits with a remark by Wittgenstein (Section 36 in his *Philosophical Remarks* […]), where he envisions the possibility of things that are neither existent nor nonexistent. This was a puzzle for philosophers." (Omnès 1994, 540 f.)

Notably, the opposite number sentence for *Philosophical Remarks* 36, namely *Philosophical Investigations* 50 – "If everything that we call 'being' and 'non-being' consists in the existence and non-existence of connections between elements, it makes no sense to speak of an element's being (non-being) […]" – is quoted, by way of introduction, by David Mermin, a leading proponent of Quantum Bayesianism (or rather, of the more radical QBism, which evolved from it), in "What Is Quantum Mechanics Trying to Tell Us [1]". (Mermin 1998, 2)

But Wittgenstein's most ardent adherent among QBists is Christopher A. Fuchs, one of the founders of QBism, as documented in the following and many other references in his massive paper (de facto, a collection of scientific letters to and from colleagues), "My Struggles With the Block Universe": "Actually Wittgenstein has become my latest addiction. In preparation for writing my new paper with Schack – one that we've been tentatively calling 'On Quantum Certainty' – I thought I should read Wittgenstein's book 'On Certainty' […]. Within the first five pages of that 90 page book, he already said all that Rüdiger and I ever wanted to say and just kept going. Here is a man who, 52 years ago, could have tackled the Penrose question head on: How a pure quantum state can be epistemic and yet still give probability one predictions for some measurements?" (Fuchs 2014, 793 f.)

And finally, a most remarkable passage from a study on "EPR-type correlations from the perspective of the relational interpretation of quantum mechanics", expounding "a novel point of view on quantum theory, denoted Relational Quantum Mechanics (RQM)" (Smerlak/Rovelli 2008, 1): Its authors employ four significant sentences from the ontology-section of the *Tractatus* to explicate the central point of their theory. After explaining what they call "Einstein realism", they state:

"RQM departs from such strict realism. In RQM, physical reality is taken to be formed by the individual (facts[3]) through which interacting systems (objects[4]) affect one another. Quantum events are therefore assumed to exist only in interactions[5] and (this is the central point) *the character of each quantum event is only relative to the system involved in the interaction."* (Smerlak/Rovelli 2008, 2)

In three footnotes, they specify the three Tractarian catchwords "facts", "objects", and "interactions", namely:
[3] "1.1 The world is the totality of facts, not of things"
[4] "2.01 An atomic fact is a combination of objects (entities, things). 2.011 It is essential to a thing that it can be a constituent part of an atomic fact"
[5] "2.0121 There is no object that we can imagine excluded from the possibility of combining with others" – thus translating Tractarian notions into corresponding aspects of a bold and still young quantum interpretation that regards the quantum mechanical description of reality as complete. This reality, however, may be different for different observers – which "is the idea at the basis of RQM." (Smerlak/Rovelli 2008, 9)[16]

Vongehr, in a discussion of his paper "Realism escaping Wittgenstein's Silence: […]" (2012), gives strong support to Rovelli and Smerlak: "Wittgenstein's role is ever more re-appreciated, see for example the pioneers of Relational Quantum Mechanics that resolved EPR […]. One needs to understand the core of Wittgenstein, not focus on his choice of words at the time or suchlike."

Friederich (2011, 2015), who "favors what he calls a therapeutic approach to interpreting quantum theory", took "his cue from the later philosophy of Ludwig Wittgenstein". (Healey 2016, 17) In the spirit of the "Philosophical Investigations" (see, for instance, §§ 116, 133, 255), it applies Wittgenstein's "radically innovative conception of philosophy" of "dissolving philosophical problems" (Friederich 2015, 6) to quantum theory, namely by analyzing "practices ('forms of life') in which these problems seem to arise" (Friederich 2011, 3, footnote 12) and in which the language-game of quantum theory is embedded. He starts by enquiring whether, e.g., the measurement problem might not arise "from a distorted perspective on how the quantum theoretical formalism connects to physical reality" and whether "the foundational problems might not vanish after certain conceptual presuppositions […] have been corrected" (Friederich 2015, 49), and advocates the Wittgensteinian concept of a "*dissolution* of the measurement problem, contrasting it with that of a *solution*" (ibid., 8) by showing that quantum states do not represent any objective features of reality but rather reflect "the epistemic conditions of those who assign them" (ibid., 7).

9. Some closing remarks

The impetus to this paper was given mainly by Zeilinger's pronouncement that Wittgenstein was a "naive philosopher of classical physics" and his critical juxtaposition of *Tractatus* 1 with his own special version of it in "Einsteins Schleier" for final effect. As a proponent of the Copenhagen interpretation of quantum physics, Zeilinger states in his book that it is not possible to make a statement about the properties of a particle before observation – in other words, *"it is senseless to talk about things that are principally unknowable"* (Zeilinger 2003, 167). Wittgenstein, in *Tractatus* 7, expressed a very similar thought almost a century ago, and in a deeper sense at that. It is demonstrably quoted, for good reason, over and over not only in connection with the Copenhagen interpretation: Smerlak (2006, 26), e.g., in an explanation of the concept of locality in RQM ("[…] locality constitutes […] the base of the relational methodology: an observer must not, and cannot, account for events involving systems located out of its causal neighborhood […]") remarks: "We can take this observation as an echo in fundamental physics of the celebrated: 'Whereof one cannot speak, thereof one must be silent." (ibid., footnote 4) And very probably, *Tractatus 7* inspired John Bell to title his collected writings "Speakable and Unspeakable in Quantum Mechanics" (1987).

Tractatus 7 would surely have made an excellent closing sentence also in Zeilinger's "Einsteins Schleier".

Philosophy begins where physics ends,
and vice versa.
(Sean Carroll, 2014)

10. Conclusions

Contrary to conventional wisdom, Wittgenstein's thinking did definitely not persist within the bounds of classical physics. Proof of an abundance of citations in the *Nachlass* plus compelling circumstantial evidence confirm that Wittgenstein was knowledgeable in the theory of relativity. As for quantum theory, already in the *Tractatus* some central concepts can be shown to contain affinities to it. Thoughs from several of his works even inspired certain aspects of current interpretations of quantum theory.

Zeilinger's supposedly corrective "quantum mechanical amendment" to *Tractatus 1* – the starting point of this paper – is exposed as a mere condensation of thoughts that are stated anyway in the course of the *Tractatus*, and is therefore redundant.

ANNOTATIONS

Note: The paper in hand is an extended and improved version of the German original, "Zeilinger, Wittgenstein und die moderne Physik oder Wie naiv war Wittgenstein?" http://www.information-philosophie.de/?a=1&t=8401&n=2&y=5&c=29**,** and of the first and second versions submitted to philpapers.org

[1] All of the author's translations from German to English are marked with asterisks

[2] To name but a few examples:

Albert, David: On the Origin of Everything
http://www.nytimes.com/2012/03/25/books/review/a-universe-from-nothing-by-lawrence-m-krauss.html?_r=0

Carroll, Sean: Philosophy Begins Where Physics Ends, and Vice Versa
https://blogs.scientificamerican.com/the-curious-wavefunction/philosophy-begins-where-physics-ends-and-vice-versa/

Carroll, Sean: Physicists Should Stop Saying Silly Things about Philosophy
http://www.preposterousuniverse.com/blog/2014/06/23/physicists-should-stop-saying-silly-things-about-philosophy/

Hsu, Steve: Does Philosophy Make You a Better Scientist?
http://www.preposterousuniverse.com/blog/2009/07/06/does-philosophy-make-you-a-better-scientist/

Norris, Christopher: Hawking contra Philosophy
https://philosophynow.org/issues/82/Hawking_contra_Philosophy

Romano, Carlin: Cosmology, Cambridge Style: Wittgenstein, Toulmin, and Hawking
http://www.chronicle.com/article/Cosmology-Cambridge-Style-/124568/

[3] Private communication from Oskari Kuusela: August 29, 2017
The complete sentence reads as follows: "I completely agree that the record for Wittgenstein's views on science should be corrected."

[4] *"*Einstein's Veil: The New World of Quantum Physics*"*. The word "veil" refers to Einstein's classic words about de Broglie's doctoral thesis of 1924: "He has lifted a corner of the great veil."

[5] Zeilinger's numbering is erroneous; it should be *Tractatus **1***!

[6] Zeilinger's "too narrow" ("zu beschränkt") is strikingly reminiscent of Heisenberg's "too narrow" in the famous interview about quantum theory and language http://www.fdavidpeat.com/interviews/heisenberg.htm : "In the Tractatus, which I thought too narrow, he always thought that words have a well-defined meaning." But also Heisenberg is wrong: For normal language, Wittgenstein's use-theory of meaning applies already for the *Tractatus* (3.261 f., 3.3, 3.326, 3.314. 3.326, 3.328 ….)

[7] http://derstandard.at/1319182381584/Wittgenstein-Memorial-Symposium-zum-60-Todestag-des-Philosophen (article not signed by name)

[8] ""The world is everything that is the case.' This is a classical viewpoint, a quantum state goes beyond. It represents all possibilities of everything that could be the case." (Zeilinger 1999a, S296)
"In quantum mechanics, we cannot make statements about what is the case, but only statements about what could be the case." (As quoted in Pirner 2015, 59)

[9] Ironically, the romantically irrational and anti-scientist Zeitgeist of the bourgeois-academic milieu of the Weimar Republic, with its rejection of determinism and causality – embodied in the powerful, if multi-faceted ideology of *Lebensphilosophie* – may have contributed considerably to the success of quantum physics in the 1920s. These tendencies also influenced Wittgenstein's thinking, which can already be noticed in several sentences in the *Tractatus* dealing with "life" (Goeres 2000, 199). Paul Forman's controversial externalist theses, which postulate a causal correlation between this Weltanschauung and the development of quantum physics surely apply to a certain degree but probably cannot be upheld in a strict sense. (Zoehrer 2016, 60-81)

[10] Zeilinger's pronouncement (*"a naive philosopher of classical physics"*) before the Austrian Academy of Sciences in November 2011 is probably based on Stenholm's book (published in September 2011), although no such strong wording could be found there; its jacket boasts a glowing recommendation ("a really unique book") by Zeilinger. It should be kept in mind that the book is only about quantum physics and not about relativity theory, which is also part of modern physics.

[11] Private communication: email August 13, 2015
(Note that Brock co-published a Wittgensteinian account of modern physics which has actually been used in experiments at CERN:

Brock, Steen and Harré, Rom 2016: *Nature's affordances and formation length: The ontology of quantum physical experiments*, SATS Northern European Journal of Philosophy
https://www.degruyter.com/view/j/sats.2016.17.issue-2/issue-files/sats.2016.17.issue-2.xml

[12] Private communication: email August 17, 2015

[13] There is another irony here:
Timpson, according to David Wallace one of the relatively few Wittgensteinians "in very science-oriented philosophy", whose "book on quantum information is heavily influenced by Wittgensteinian ideas" ("Wittgenstein's neglect", comment No. 15 by David Wallace, http://www.newappsblog.com/2013/06/wittgensteins-neglect-1.html), explains in his discussion of "two distinct formulations" of Zeilinger‘s "Foundational Principle for Quantum Mechanics" (Zeilinger 1999b) that "Zeilinger‘s approach here bears marked similarities to Wittgenstein's views in the *Tractatus Logico-Philosophicus*" (Timpson 2013, 153, footnote 128)! (Author's note: especially *Tractatus* 4.2 – 4.2211; Timpson refers to the fact that Zeilinger's Foundational Principle is highly reminiscent of Wittgenstein's "elementary propositions describing basic objects".) For the sake of completeness, it should be added that Timpson uncovers various pitfalls and confusions in the current debate in general, and that despite Zeilinger's baffling nod to Wittgenstein, he does not seem to be very much taken with Zeilinger's quantum philosophical cogitations.

[14] Private communication: email August 18, 2015

[15] Private communication: email August 13, 2015

[16] In a Wittgenstein-inspired paper like Smerlak/Rovelli's, a sentence such as "Reality may be different for different observers" is necessarily reminiscent of the early Wittgenstein's solipsism as developed in the *Tractatus*, 5.6 – 5.641. But Rovelli vehemently rejects even the faintest reproach of solipstic tendencies in RQM here (2008, p.6) and elsewhere (e.g., "ridiculous philosophical views like Berkelian Idealism or outright solipsism", as quoted in Bernard d' Espagnat and Hervé Zwirn (eds.), The Quantum World: Philosophical Debates on Quantum Physics, 2017, p.202). And yet, it seems to remain a disquieting notion to some quantum thinkers of various ilks, who thus try to circumvent their predicament by introducing terms like "multisolipsism", "convivial solipsism", and the like.

Acknowledgements

I am grateful to
Paulo Cesar Bezerra, Faculdade de Engenharia Elétrica e de Computação, UNICAMP, Campinas, São Paulo, Brazil
Steen Brock, School of Culture and Society, Aarhus, Denmark
Karl Czasny, Vienna
for generously sharing with me their scholarship in the area via extensive email correspondence;
August Fenk, Alpen-Adria-Universität Klagenfurt
for invaluable advice and comments;
Oskari Kuusela, University of East Anglia,
for his sound advice and for his moral support;
and to Alois Loidl, Institut für Physik, Universität Augsburg,
for facilitating my access to information from the Oxford HAPP-Conference "Wittgenstein and Physics"

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