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“On nature, its mental pictures and simulatability. A few genealogical remarks.”

Let me start with a quote of a work already cited yesterday, Richard Feynman's “Lectures on Physics” of the early 1960s: In a chapter titled “Scientific Imagination” he’s asking what one would see if one would be able to see electromagnetic waves:

> “What do / actually see? What are the demands of scientific imagination. Is it any different from trying to imagine that the room is full of invisible angels? No, it is not like imagining invisible angels. It requires a much higher degree of imagination to understand the electromagnetic field than to understand invisible angels. Why? Because to make invisible angels understandable, all I have to do is to alter their properties a little bit [...] which is [...] relatively easy.

> So you say, ‘Professor, please give me an approximate description [...]’ - I'm sorry I can't do that for you. [...] When I start [...], I speak of the E- and B fields and wave my arms [...] I see some kind of vague shadowy, wiggling lines—here and there is an E and B written on them somehow, [...] I have a terrible confusion between the symbols I use to describe the objects and the objects themselves.

> I cannot really make a picture that is even nearly like the true waves [...]. Perhaps the only hope, you say, is to take a mathematical view. [...] From a mathematical view, there is an electric field vector and a magnetic field vector at every point in space; [...] there are six numbers associated with every point. Can you imagine six numbers associated with each point in space? That's too hard. Can you imagine even one number associated with every point? I cannot! I can imagine such a thing as the temperature at every point in space. That seems to be understandable. There is a hotness and coldness that varies from place to place. But I honestly do not understand the idea of a number at every point.”(5239,760)

1 Talk on “Interferences Events, Epistemic Shifts in Physics through Computer Simulations, Symposium, Jan 20-21, 2016, Mecs, Leuphana University Lüneburg"
This is the Richard Feynman of the early sixties, lecturing undergraduates at Caltech. We don’t find a word about Bell’s inequalities, because these preconditions of any experimental proof of quantum entanglement were still unknown to the physicists at that time. The EPR Paradox is mentioned explicitly by Feynman though, in the end explained in an original way by the uncertainty principle.

But this is not the reason why I quoted this Angel statement of Feynman wiggling in the air and seeing numbers in space. What interests me, is firstly, that Feynman comes up with a question of “what is”; secondly how he thereby embraces “scientific imagination”, thirdly how he incites to solve the problem, and fourthly how peculiar and odd he is talking about this topic.

To put it in more general terms: depicting electromagnetic waves, as this little sketch already shows as, should be rendered as an ontological, phenomenological, symbolical, epistemological and also an ethical or meta-ethical problem.

(a) Ontologically one has to admit, Electromagnetic waves have a reality, but a very special one, possibly in the way Niels Bohr spoke about “different levels”(9350,89) of reality where “conceptions like realism and idealism find no place in objective description as we have defined it”;

(b) Phenomenologically there can be no doubt: at least as much as real entities these waves are phenomena. As George Greenstein reminds us, “an electromagnetic wave is detected by monitoring its effect on charges—charges in, for instance, an antenna.”(9343, 83);

(c) Thus detected as phenomena in reality, from the outset on electromagnetic waves have been shaped of symbolic mathematical descriptions rather than of empirical experiences. As is well-known, Feynman six numbers at every point in space apply to Maxwells equations which, as I will show you soon, guided Hertz experiments to success.

(d) On this realistic, phenomenological and symbolical level electromagnetism has to be understood as an object and subject of a new scientific setting, opening up a new
epistemology, as Karen Barad puts it, as “a nondualistic whole marking the subject-object boundary”. Or with Niels Bohrs words: Different to “the scope of classical physics, where the interaction between object and apparatus can be neglected […], in quantum physics this interaction thus forms an inseparable part of the phenomenon” (9342,136).

Eventually, concerns of ethics just draws the consequences of what I said about the epistemology, reality and phenomenology of electromagnetism. As much as it comprises, on a basic quantum level, fundamental interactions between particles and wave mechanisms, since the last 120 years electromagnetism has been responsible for the groundbreaking successes of all new medial cultural techniques on a technological level. Electromagnetism, from the moment on it came to existence as a technical phenomenon, encapsulates, in the sense of Donna Haraway, a long story in itself, still ongoing by the way, because it would never had come into existence and never would have grown to such a worldwide dominance outside the subject-object connection of cultural techniques, nor outside the material, economically driven nature-culture discourses of scientific practice. According to Bohr, as Karen Barad resumes: “The central lesson of quantum mechanics is that we are part of the nature that we seek to understand” (9342,265).

Not just John von Neumanns solutions of the quantum mechanical measurement problems, as I have shown elsewhere, but already the basics of quantum theory itself have laid ground to the cybernetic feedback models in the sense of Norbert Wiener. In contrast to this, Karen Barad emphasises a new "ethico-onto-epistemic attention to our responsibilities not only for what we know" (9342,382) but also, of course, for what we don’t know yet.

My genealogical remarks start off with Heinrich Hertz around Christmas Days of 1887. Experimenting in his lecture hall in Karlsruhe, luckily built purely by wood in the walls and ceiling, all the light he might have seen through the windows consisted of waves as it was known at least since Fresnels proof of diffraction of 1819. For sure he knew, but their connection to electricity was still more than dubious.

Not earlier than 1873, just 15 years ago, in the second volume of his “A Treatise on Electricity And Magnetism” James Clerk Maxwell stated: “we shall have strong reasons for believing that light is an electromagnetic phenomenon” (5325,409). Long ten years later
the two volumes were translated in German. After one year of research, in the Christmas days of 1887, Heinrich Hertz had indeed to fulfill this impossible Feynman task to make electromagnetic waves seeable and also verifying these waves as identical with light.

I don’t want to go too much in the detail of why and how Hertz started off with his experiments. All began in late winter 1886 with this scenario, an Ruhmkorf inductor amplified by two big condensers spilling out discharge sparks, received again through sparks spraying off from some receiving devices.

As is well known, Hertz was part of the agent network of Herman von Helmholtz, who was working on the most important posts in German Physics very engaged in clarifying the fundamental differences between the german nature-romantical theory of electricity and the much more successful scientific approaches in the leading industrial nation Great Britain. To the dismay of the majority of german physicists Helmholtz had translated Thomson and Taits “Natural Philosophy” as a students textbook in 1871, explicitly lining up himself on the side British against the kantian transcendentalism in Germany. In those days Helmholtz got the reputation as an rude materialistic thinker denying the deep interconnections between the transcendental truth of nature and the human spirit, “dem menschlichen Geist”.

As a matter of fact, the crucial point in this dispute was the still undecided question, of whether electricity could be a potential force with partly immediate distant effects or should be conceived as a force of disturbances propagated by a so called “displacement current” along wires as well as without any carrier freely through space.

Of course, also Hertz didn’t see any electromagnetic waves at all. What he saw were sparks. Only recognisable with special microscopic lenses, tiny little sparks were oscillating in the slits of his receiver rings, when he posted them on special point in his hall,
luckily a room without any iron in its walls and ceilings, otherwise everything would have
gone wrong, as so many failed replications of his experiments have shown painfully.

Hertz experimental setting was simple sparks receiving sparks circuit, but at the same
time extremely cumbersome and delicate. From the so called Feddersen Photo
experiments of the 1850ties he knew a lot about the interior of
discharging sparks, namely that they include damped oscillations
of alternating currents floating back and forth between the poles of
the Ruhmkorff-Dipol. “It has long been known that the discharge of
a Leyden jar is not a continuous process, but that, like the striking
of a clock, it consists of a large number of oscillations, of
discharges in opposite senses which follow each other at exactly equal intervals.”
Interestingly Hertz considers this property a simulation, as he continues:

“Electricity”, to explain how it works in sparks, “is able to simulate the phenomena of
elasticity.” (9385,353/376)

Given all elasticity, rather more chaotic things seemed happening in the slit-pole of the
receiving curls. Hertz knew, that he could
never compute the receiving spark-
frequencies there. With micro-lenses, it just
worked to observe the strength and the
brightness of the sparks. One can imagine
how tedious Hertz was thickening with his
pencil the specks on his floor plan where
sparks looked brighter than elsewhere.
Operating with metal mirrors and huge lumps
of pitch, he proved also in principle the
similarities of electromagnetism and light by
reflection and refraction characteristics. In the end, after one long year of countless tests,
Hertz got a few rough calculations of the possible frequencies which, divided through the
velocity of light, provided him theoretically with the length of his presumed waves. But, we
are in a three dimensional room …

… and unfortunately, even Maxwell had not really entertained calculations of free
propagating “disturbances” in spherical spaces. Above all, his mathematics was all but
clear to his english contemporaries, let alone to a german physicists, who was trained in
differential equations of Neumann and Weber potential expressions but by no means able to work with quaternions and pre-vector mathematics Maxwell is using in his treatise. The elegance of the four Maxwell equations as we know them today, is in fact a reduction of about twelve in his book, in a ten year long work done by Josiah Gibbs and Oliver Heaviside after Hertz death. However Hertz’ waves in 1887 look like, elasticity simulating or not, it surely was nothing two dimensional.

Hertz had to delve now into the very complicated mathematics of Spherical Harmonics in Maxwells first volume, as his Ruhmkorff dipol did spill out waves not only in a linear plane, but also rather curved in all possible directions. And above all, at a certain frequency, his waves peeled off and moved on as an autonomous electromagnetic field or just electromagnetic wave radiation.

On the level of contemporary scientific practise, nobody could know what was really happening here. Therefore Hertz had to grapple for something intelligible which could give him a picture of what was happening here, a “inneres Scheinbild” as he would call it later on. I come back on that. Indeed, he pictured to himself the inner processes in the discharge sparks.

“The period of a single oscillation” Hertz wrote, “is much shorter than the total duration of the discharge, and this suggests that we might use a single oscillation as a sign”. Hertz wrote this two years after, telling the story of his experiments to the German Association for the Advancement Of Natural Science And Medicine. ‘Taking the oscillation which he couldn’t see as a sign to identify something unseeable’. This sentence I would like to highlight here, because it makes clear what Hertz was really concerned with. It were not only sparks he had to receive. He had also to solve an epistemological problem. His sparks didn’t just receive sparks, although these were the phenomena. But for Hertz in every spark was something unseeable like a
furious mixture of abating frequencies caused by the oscillations slackening up by and by. Feddersen Photos didn’t show them either, but gave at least a hint. Reproducing all these frequencies of a Ruhmkorff spark on his floor-planes was impossible. Instead, here comes the “inneres Scheinbild”: Hertz had to construct just one of them, or say reconstruct one of them, in estimating length and shape of one wave, via wave superpositions getting brighter receiving sparks to locate its shape more precise in the room, and this all in the reality of thousands upon thousands other waves of other frequencies swooshing around in his room. In other words, he had to built up a precise and conscious intra-action between his apparatuses and the effects he want’s to identify.

“When you discharge the conductor of an electrical machine” says Hertz “you excite oscillations whose period lies between a hundred-millionth and a thousand-millionth of a second […] There is still the possibility of success if we can only get two or three such sharply defined signs.” The german original not unimportant here: “scharfe Zeichen”. Please remark this unusual German expression, actually a bit unclear. What is the sharpness of a sign? Clear and distinct, yes, but sharp? Maybe Feddersen, the view into the spark-photographies, is reverberating here. “Scheinbilder”.

These now, two years later, are the harmonic spheres of Heinrich Hertz, very similar to Maxwells picture I’ve shown before. Seen in the strict perspective of Ernst Mach epistemology, all Hertz had done was kind of wrongly inferred. “For Mach a physical theory was no more than an abbreviated expression for a collection of statements about sense-data. Terms which could not be grounded in sensory experience were not to be retained in scientific discourse, and theories appealing to unobservable or indirectly observable entities - the electric waves of Hertz or the atoms and molecules of Boltzmann’s statistical mechanics - ultimately were to be cast out as metaphysical superstitions.”(Barker,0112,4/14) as science historian Peter Barker said it. “Hertz on the other hand argued that […] at the level of experimental observation, the correlation of sentences in the theory with phenomena in the world is [strictly and only] imposed by ourselves, […].” Hertz epistemology says, that “a physical theory has a given structure is never a guarantee that reality has this structure.” 0112barker (page 4 of 14)"
That is to say: Given the curves of Maxwells theory, “we find as many points on the curve as we please”. Let’s be clear. Hertz is not faking his result. Although the curves are given here as a blueprint of his results, this is just one phase of his complex workflow. It is a phase and a part of his new intra acting approach to scientific practise.

For the last time, let’s go back to the key device of Hertz and let’s what he has to say how his mix of a simulative and experimental setting had worked out. “Just at the spot where we wish to detect the force” he explains, “we place a conductor, [...] interrupted in the middle by a small spark-gap. The rapidly alternating force sets the electricity of [this receiving] conductor in motion and gives rise to a spark at the gap. The method had to be found by experience, for no amount of thought could well have enabled one to predict that it would work satisfactorily. For the sparks are microscopically short, [...] It almost seems absurd [...] that they should be visible.”

Well, nothing is absurd here. It’s a mixture between a thought simulation and a prove by data. Most likely, Hertz climbed on his ladder only at those spots in the room where some theoretical computation in advance had already forecasted seeable sparks. Because detecting sparks on a not expected place would mean nothing, whereas not seeing sparks on an expected spot would mean at best a failure of the apparatus. Thus, Hertz performed a growing-in-practice and self-referential intra-action between his apparatus and the theory, both proving, amplifying and giving shape itself in a feedback loop.

Electromagnetism had to be discovered that way, or, to say it the other way round, in a Latourian turn, electromagnetism produced it’s way to be detected as well. Let’s consider, Hertz didn’t know anything about the interaction between photons and electrons, the discovering of the electron was still ten years ahead, Plancks action quantum twelve years and Einsteins detection of the relativistic invariance of the electromagnetic waves another eighteen years away. About forty years ahead laid the definition of the uncertainty principle, Copenhagen complementarities, Schrödingers equation, Dirac’s Brackets and von Neumanns Hilbert Space. Nevertheless, Hertz experimentation shows already all
parts of the later quantum mechanical concept of nature. With and after Hertz nature is not any longer an object of observation which remains untouched. Untouched nature, as Peter Mittelstaedt put it, is a nature “without relation to the possibly of observation” (0471,6/10). On the contrary, observation of nature in terms of physics is always a process of changing the observed, of constructing a new world of ontological facts which are at the same time real phenomenons, intelligible noumena and subjects of empirical verification.

And, with Hertz, there are media! Let’s not forget, electronic media starts with Hertzian waves, ironically 1894, with Oliver Lodges experiment in Liverpool, as a commemoration on behalf of Hertz’ death. Electronic media, from radio telegraphy to the internet computer world, are based on the quantum mechanically produced chips as well as on electromagnetism and underlies the same epistemology, ontology, phenomenology and ethic.

But Hertz didn’t anticipate that. Being asked by an engineer whether his “rays” could transmit Telephone he replied honestly no! Facilities of modulating electromagnetic frequencies up and down didn’t exist at his time. And, he died before these weird folks like Edison and De Forest 15 years later came around tinkering with light bulbs and cathode rays not knowing what the were doing but thus inventing the radio tube.

Moreover, as physicist Hertz had to cope with a far bigger dilemma. Electromagnetic waves demanded a medium for propagation, at his time called ether. But on the other hand he knew all about the almost absurd qualities which this material should comprise, for example, absolute transparency for ponderable matter and at the same time an absolute density, even harder as diamond, thereby behaving totally elastic to propagate transversal waves.

Hertz and Maxwell lived in the world of the ether absurdities, against which all possible inconsistencies of our quantum world look
like a child play. William Thomson, the great Hero of Helmholtz, had famously proposed his so called Vortex Atom Model in the 1860s. While Hertz in Kiel and Karlsruhe had to teach Weber and Naumann “acting in distance” electricity, George Fitzgerald came out with this rotating model of ether molecules. After Maxwell published his theory in the 1870ties, countless models came up of how electricity would travel through this rolling balls. Hertz didn’t live to see J.J. Thomson’s electron detection anymore and the subsequent Plum Pudding Atom Model after 1897. My point is here, all these concepts, including the Weber/Neumanns action in distance electricity molecules, had one ontological assumption in common …

… and that is nature as a continuously comprehensive entirety, nature as a objective reality which doesn’t jump. “Natura non facit saltus” had been one of the main principles of modern physics from Leibniz on, who first coined this "continuity law": «c'est une de mes grandes maximes et des plus verifiées, que la nature ne fait jamais des sauts». This yielded a static epistemological horizon enabling subsequently the assumption that nature could be totally measurable with infinitesimal tools. More importantly, this same assumption let emerge consequently the demand of a “completeness” of all theories dealing with a nature without jumps, called continuity physics. For instance, Heisenberg, still in 1955, referred to this continuity principle like an iron premiss. But he gave a very “Bohrian” answer. … “our knowledge can change suddenly and that this fact justifies the use of the term “quantum jump”.”

Long before quantum physics also Hertz took already another course. After having done his great experimental year with electromagnetics, he started reconfiguring the relation between object and observer, subject and object, nature and culture, theory and practice. Explicitly and fraught with consequences.

In the preface of his last book about Mechanics we read: “We form for ourselves mental pictures or symbols of external objects; and the form which we give them is such that the necessary consequents of the things pictured.”
pictures in thought are always the pictures of the necessary consequents in nature of the things pictured.” Again, Heinrich Hertz is choosing his words very carefully. Especially the German word “interne Scheinbilder” deserves a closer look.

Hertz follows Maxwell not only on the material level. He does it also in his epistemology, including a smart and almost inconspicuous renunciation of the continuity principle. My theory, Maxwell had written, leads “to the conception of a medium in which the propagation takes place” We know, that is the ether, never experimentally proved, but violently claimed and widely believed because of the continuity principle. “If we admit this medium as an hypothesis, I think […] that we ought to endeavour to construct a mental representation of all the details of its action, and this has been my constant aim in this treatise.”

How smart. Maxwell conceived electromagnetic waves as ether-waves, regardless of ether exists or not. Here we already see his careful decoupling from a nature as such and a theory of nature, a decoupling, which leads to the concept of a “mental representation”, surely the role model of Hertz “Scheinbild”. If the continuity principle for Maxwell would have been still the guideline, the question would have to be: what is the mental representation of ether besides electricity? Maxwell’s Answer: I don’t have one, and I don’t care. By the way, this is the reason why Thomson rejected the ideas of Maxwell as long as he could.

To the end of my talk I would like to undertake with you a very short closed reading of this paragraph including its reception through Boltzmann, Wittgenstein and Cassirer.

The first striking thing in the sentences is again the self referential move of the argument. To give pictures as physical concepts the ability that their necessary consequent’s should be always pictures of the necessary consequent’s of the natural things pictured. We weave a carpet of paradoxes which can only be resolved in the performance of scientific practice. According to this theory, what is
happening in observing nature, is an intra-action of pictures into pictures where the difference between one and the other is infected by apparatuses which encapsulate nature in a concept which Karen Barad has coined “agential ontology”. The “certain conformity between nature and our mind” demanded by Hertz wouldn't work if either nature is not part of our mind or mind would be an agent completely different from nature. Indeed, this is a hidden variable, maybe the only necessary one in modern relativistic and quantum physics after Hertz, but if so, then also ethics is demanded.

“When from our accumulated previous experience”, Hertz continues, “we have once succeeded in deducing pictures of the desired kind, we can then in a short time develop by means of them, as by means of models, the consequences which in the external world only arise in a comparatively long time, or as the result of our own intervention. We are thus enabled to be in advance of the facts, and to decide as to present affairs in accordance with the insight so obtained.”

In my view, the following sentence articulates the most striking and surprising thought of Hertz because it expresses an explicitly incomplete ontology, or put it the other way around, an ontology of incompleteness: “The pictures which we here speak of” says Hertz, “are our conceptions of things; with the things themselves they are in conformity in one important respect, namely, in satisfying the above-mentioned requirement. For our purpose it is not necessary that they should be in conformity with the things in any other respect whatever. As a matter of fact, we do not know, nor have we any means of knowing, whether our conceptions of things are in conformity with them in any other than this one fundamental respect.”
fundamental respect”. Unfairly enough I recall here the discussions about complementarity decades later in the 1920s. But Hertz pleads here, quite explicitly, for an ethic of a Not-Knowing, since we will never know what a nature in itself would be. There is no continuity principle anymore in the world view of Hertz’ scientific thinking.

“As whether only matter exists and force is a property of it,” adds one of the biggest fans of Heinrich Hertz, "or whether force exists independently of matter or conversely whether matter is a product of force [...] none of these questions are significant since all these concepts are only mental pictures whose purpose is to represent phenomena correctly”. Again, referring to Karen Barads agential realism, with Boltzmann we are in the same epistemological boat. The only existing things in nature are phenomena produced by a scientific practice led by mental pictures and symbols, but these phenomena are also enacted and acted out by nature. This is surely a proper idea of Niels Bohr whose work is impressively resumed in the propositions of Karen Barad, but which is also already present in the scientific thought of Ludwig Boltzmann as a reader of Heinrich Hertz.

I skip now my slide about Wittgenstein …

Wittgenstein adopts Hertz’s vocabulary for his own account of the relationship between language and the world, cf. Tractatus Logico-Philosophicus (1921):

1 We make for ourselves pictures of facts. (Wir machen uns Bilder der Tatsachen.)
2 A picture is a model of reality (Das Bild ist ein Modell der Wirklichkeit)
2 A picture depicts reality by representing a possibility of existence or non-existence of states of affairs (Das Bild bildet die Wirklichkeit ab, indem es eine Möglichkeit des Bestehens und Nichtbestehens von Sachverhalten darstellt)
2 A picture represents a possible situation in logical space (Das Bild stellt eine mögliche Situation im logischen Raum dar)
2 If it were impossible to draw up a picture of the world (true or false), Es wäre dann unmöglich, ein Bild der Welt (wahr oder falsch) zu entwerfen.

… and Cassirer.
and go straight ahead to my last slide showing the Einstein Podolsky and Rosen article of 1935.

I would have said to Wittgenstein of 1917 and Cassirer of 1923 that they developed a total philosophy out of Hertz thoughts, on the one hand a philosophy of language, on the other a philosophy of symbols. Either way, in their reception they both left aside one main point of Hertz epistemological remarks, and this is what we are missing now in the following considerations.

“Any serious consideration of a physical theory” Einstein and his colleagues wrote, “must take into account the distinction between the objective reality, which is independent of any theory, and the physical concepts with which the theory operates. These concepts are intended to correspond with the objective reality, and by means of these concepts we picture this reality to ourselves.”(9245,1) Of course, this refers to the Hertzian lemma of 1894, but interestingly Einstein continues differently.

“In attempting to judge the success of a physical theory we may ask ourselves two questions: (1) “Is the theory correct?” and (2) “Is the description given by the theory complete?”

As we have seen, completeness is exactly what Hertz and Boltzmann excluded out of their theory, and that is, as we know, one of their crucial arguments to get rid of continuity physics and of such of its epitomes like ether. Maybe Einstein remembers faintly something and feels he should become more verbose now: “Whatever the meaning assigned to the term complete, the following requirement for a complete theory seems to be a necessary one: every element of the physical reality must have a counterpart in the physical theory.”
There we are, at the end of my talk. The genealogical view back to Hertz I would like to sum up in the statement, that Einstein in his objection to quantum entanglements re-established the horizon of continuity physics in a discourse, which emerged from a scientific work on how to get rid of it. Maybe Hertz did that for the sake of a better world? We don't know.