Physics and Ontology
- or The 'ontology-ladenness' of epistemology and the 'scientific realism'-debate

by Rudolf Lindpointner

„But a world existing for many millions of years without any mind being aware of it, contemplating it, is it anything at all? Has it existed? For do not let us forget: to say, as we did, that the becoming of the world is reflected in a conscious mind is but a cliché, a phrase, a metaphor that has become familiar to us. The world is given but once. Nothing is reflected. The original and the mirror-image are identical.“[1]

Abstract:

The question of what ontological insights can be gained from the knowledge of physics (keyword: ontic structural realism) cannot obviously be separated from the view of physics as a science from an epistemological perspective. This is also visible in the debate about 'scientific realism'. This debate makes it evident, in the form of the importance of perception as a criterion for the assertion of existence in relation to the 'theoretical entities' of physics, that epistemology itself is 'ontologically laden'.

This is in the form of the assumption that things (or entities) in themselves exist as such and such determined ones (independent of cognition, autonomously). This ontological assumption is not only the basis of our naïve understanding of cognition, but also its indispensable premise, insofar as this understanding is a fundamentally passive, 'receptive' one. Accordingly, just as 'perception' is the foundation, ('objective') description is the aim of cognition, that which cognition is about. In this sense, our idea of cognition and our idea of the things are inseparably linked. Without the ontological premise mentioned we just would not know what cognition is, but it is basically just a kind of image that we have in our minds (an assumption that helps us understand 'cognition').

Epistemology not only shares this basic assumption (which it also shares with metaphysics), but it revolves (unlike metaphysics) entirely around it by making the idea and demand of 'certainty' a condition of 'real' knowledge. As 'certainty' is a subjective criterion this entails the 'remodelling' of the real, holistic cognitive situation (to which metaphysics adheres) into a linear subject-object-relation (which results in the strict 'transcendence' of the objects). And it also establishes, due to its 'expertise' in matters of cognition, the 'primacy of epistemology' over all other sciences.

Now, on closer inspection, however, the expertise of epistemology seems not all that dependable, because it basically consists only of paradigms which, from the point of view of the holism of the real cognitive situation itself, are nothing more than relatively simplistic interpretations of this situation. However, we do not yet know what another conception of cognition might look like (which is not surprising given the high rank of the phenomenon of cognition in the hierarchy of phenomena according to their complexity). 'Certainty' as a criterion of cognition is thus excluded from the outset, and thus the linear relational model of cognition appears as what it is, a gross distortion of the real, holistic cognitive situation.

The significance of this argumentation with regard to physics is that the linear epistemological model of cognition itself is a major obstacle to an adequate epistemological understanding of physics. This is because it is fixed 'a priori' to an object-related concept of cognition, and to 'description' as the only mode of ('real') cognition. But physics (without questioning our naïve notion of cognition on the level of epistemology) simply works past it and its basic assumptions. Its cognitive concept (alias heuristic) is fundamentally different from that of metaphysics. The acceptance of the real, holistic cognitive situation is, in my opinion, the condition for an adequate understanding of physics' heuristic access to objects, its transcendental, generalizing cognitive concept, as well as its ontological relevance and dimension of its own.

Table of content:

1 Schrödinger, E. (2018), p. 135f.

0. Introduction and prologue

The philosophical debate on 'scientific realism' concerns particularly physics and the existential status of 'physical entities'. P. Kyle Stanford describes the problem as follows: "Should we really believe that our best scientific theories simply tell us how things stood in the various inaccessible domains of nature they purport to describe? ... Or should we think of them in some other way, perhaps simply as useful conceptual tools for predicting natural phenomena and intervening to produce or prevent them ... For most of modern history ... this has been a central concern for scientist themselves ... Although today we typically describe the dispute as concerned with something we call scientific realism, at the heart of the matter is still the simple question of whether or not we should understand our best scientific theories as literally true descriptions of how things stand in nature itself. "[2]

The problem arises primarily from the fact that the 'physical entities' (including 'forces' as well as 'particles' etc.) are not accessible to direct observation, but only to observation that is highly 'theory-laden'. And the doubts are further reinforced by scientific progress, which again and again leads to fundamental revisions of theoretical concepts, implying that many theories recognized at a certain point in time turn out to be in need of revision or to be wrong, and in this sense to be 'false descriptions'.

Directly part of the problem (though not of the debate) is, as the formulation impartially expresses, the concept of cognition, namely in the form of equating (real) knowledge with (objective) 'description'. This is emphasized by the contrast to the mere (pragmatic) 'explanation' ('useful conceptual tools').[3] In the field of tension between description and explanation outlined in this way, a profound epistemological uncertainty regarding the interpretation of the cognitive concept of physics is reflected.

This is also expressed in the form of argumentation in the realism debate. For since in physical theories the 'explanatory' aspect is clearly predominant over the 'descriptive' one, but the 'descriptive' one represents the supposed reference to independent reality, the question arises from this viewpoint as to whether it is justified to conclude from the 'success of the explanation' to the 'correctness of the description' with regard to the postulated 'theoretical entities', and thus their existence, independent of the theory. Such a conclusion is e.g. the famous 'no-miracles-argument', formulated by Hilary Putnam: „The positive argument for realism is that it is the only philosophy that doesn't make the success of science a miracle“.[4] There are strong objections to this. P. Kyle Stanford, besides the doubts already mentioned with regard to the permanent progress of science (he calls this argument 'the pessimistic induction'), mentions above all 'the underdetermination of theories by the evidence' and 'the problem of unconceived alternatives'.[5]

In order to get to the bottom of the realism debate, however, it is necessary not only to exchange epistemologically based arguments, but ultimately to put the ontological premises of epistemology itself in the spotlight. What is primarily meant by this is that premise which gives perception its 'substance', which logically underlies the idea of (direct) perception (or observation) as a testimony of reality, and from which its decisive role as a criterion of legitimation for the assertion of 'reality' of theoretical entities is derived: the ontological premise of the 'determinacy of things themselves'. As far as the 'testimony of perception' is concerned, the emphasis is therefore very much on immediacy. For this reason, the thesis of 'epistemological holism' of the 'theory-ladenness of observation' (its purely indicational character) forms the hard core of the problem that is negotiated

2 Stanford, P. K. (2006), p. 5

3 In this sense James Woodward also writes on the subject of 'explanation': „My account of causal explanation: we are in a position to explain when we have information that is relevant to manipulating, or changing nature, in an 'in principle' sense of manipulation.“ (Woodward, J. (2003), p. 9f.)

4 Quoted after Ladyman, J. & D. Ross (2007), p. 69, where it also undergoes a detailed discussion. See also Stanford, P. K. (2006), p. 6ff.

5 Stanford, P. K. (2006), pp. 7-8 and 18

in the realism debate.[6] This consists, in short, in the undeniable discrepancy between the 'testimony claim' of perception coupled to immediacy and 'theoretical reality'. The problem is unsolvable on this level.
But the real problem lies deeper. The point is this: our concept of reality is, roughly speaking, that the objects of cognition are present 'objectively', that is, completely 'independent of cognition', as such and such determined (by way of an implicit mental subtraction). And this concept of reality also forms the basis of our (naïve) understanding of cognition,[7] for it consists in nothing other than the idea of the relationship of its 'contents' (perception, thought and concepts) to an autonomously (independently of cognition) determined, objective reality. The concept of reality and the (naïve) understanding of cognition are thus both defined (from different directions) by the independence of reality from cognition, with the common bracket of the 'contents' of cognition, and their view in a 'descriptive' sense. Our concept of reality and our understanding of cognition thus refer to each other, they correspond and 'require' each other. This basically makes it impossible to question the one without questioning the other.
This concept of reality logically necessitates a fundamentally passive, receptive conception of cognition (as common in empiricism). The 'passive reception', the perception through the senses, accordingly is our only access to things, and the source of the contents of thought. However, the problem that arises here, and around which the entire epistemology revolves, is that upon closer reflection it becomes clear that not all the contents of knowledge can be traced back to perception, especially not the ontological categories.[8]
The (naïve) understanding of cognition, which is based on the above mentioned concept of reality, is logically (philosophically) transformed into an object-related ('metaphysical') concept of cognition, which underlies both, metaphysics and epistemology. Traditional epistemology does not differ from metaphysics in this respect, and the philosophy of science, too assumes this as a matter of course (seethe so-called 'demarcation problem').[9] It is in this sense that I speak of the ontology-ladenness of epistemology.
However, epistemology differs fundamentally from metaphysics in another respect, namely in the construction of the cognitive situation. Classical Metaphysics starts out from the real, holistic cognitive situation, i.e. it considers the human being, the cognitive being, itself as part of that totality which it describes in a distinguishing, classifying way, and thus determines the 'essence' of each individual or species, including the human species (to which in this case also the 'cognitive faculty' belongs). At the same time, however, she combines this holistic approach (and claim to knowledge) with the naïve, receptive understanding of cognition, in the sense of cognition as immediate mental (perceiving and thinking) 're-construction'. Corresponding to this is the view not only of perception, but also of 'understanding' and 'reason' as fundamentally passive 'capabilities',

6 A logical consequence and an aspect of this fundamental thesis is the so-called Duhem-Quine thesis (the thesis of the 'underdeterminedness of a theory by observational data'). The 'non-observability' of the entities is in this sense only a further aspect.

7 I call this concept of cognition 'naïve', because although it is true that we have no other concept of cognition, and that natural science has so far not been able to offer any 'other description' (or explanation) for the 'phenomenon of cognition', it is on the other hand to be questioned from a scientific point of view for the very reason that the phenomenon of cognition is at the top of the hierarchy of natural phenomena according to their complexity. The fundamental view of cognition as a 'natural phenomenon' therefore necessarily means that the naïve view of cognition must be given a provisional status at most.

8 Kant's famous dictum: „Gedanken ohne Inhalt sind leer, Anschauungen ohne Begriffe sind blind.“ (Kant, I. (1975), p. 98. [Translation:] "Thoughts without intuition are empty, intuitions without concepts are blind." restricts himself in this tradition, as far as his own system of transcendental philosophy is concerned, to the 'determination' of the source of the (onto-logical) concepts of understanding. The source of all other concepts of thought remains out of consideration. These seem to be essentially 'taken' directly from intuition. It took pragmatism and Heidegger to fundamentally question this view.

9 The bitter opposition of philosophy of science to metaphysics is based on this (as far as physics is concerned, as will be shown) misleading conviction.

with the logical consequence (or, respectively, precondition) of 'realism about universals'.[10]

In contrast, epistemology - following the clear voice of the nominalist doubt about 'universal'-realism, but at the same time and above all following the desire for 'certainty' - radically re-models the real, holistic cognitive situation into a linear relationship, into the model of the subject-object relationship,[11] due to the proclaiming of 'certainty' a condition of 'real' knowledge (as 'certainty' is a subjective criterion). With regard to the concept of reality everything thus basically remains the same (the assumption of the autonomous determinacy of things is in itself the pre-requisite for the meaningfulness of the criterion of certainty), but the real holism of the cognitive situation now turns into a strict transcendence of objects. However, the decisive factor is not nominalism (which applies to subject and object alike), but the demand of 'certainty' (as criterion of 'real' knowledge).

In this respect I am talking about the paradigms of epistemology, which eventually also become the epistemological paradigms of the theory of science. These are paradigms of great suggestive power, to which the assertion of the 'primacy of epistemology' (its position as 'prima philosophia') is owed.[12]

The concept of reality in epistemology thus consists, roughly speaking, in the assumption of the relationship of cognition (i.e. of perception or concepts of thought) to something that exists in a distinct form and way independent of perception and thought (autonomously), in complete transcendence, that is, in a way to which we can 'approach' epistemically (in our solitary dependence on our sensory impressions and our thinking) at most in an unclear way (provided that the 'things in themselves' are not at all 'unrecognisable' due to the transcendental constitution of our cognitive faculties).

Thus, epistemology brings cognition into play as 'activity' (not merely as 'capability'), but without deviating from the fundamentally passive understanding of cognition. The idea of 'passive reception' (the 'givenness of sensory impressions') remains decisive for the understanding of cognition.[13] Supplemented by the contribution of thinking, the concept of cognition in the sense of mental reference (as activity) or mental representation (as result) is derived from this.

How does physics fit into this picture? The trilemma expressed in the realism debate (description vs. explanation or both) is due to the fact that physics (from the beginning) works past the metaphysical concept of cognition without reflecting on it epistemologically. Its approach is not the descriptive one, but the inquiring one. As we have seen, our naïve understanding of cognition is logically transformed into the metaphysical concept of cognition, which is object-related and specifying (descriptive). Just like epistemology, philosophy of science (in its footsteps) adheres to this concept, and applies it to physics (but now with a different approach towards its 'legitimation'-claim: top-down instead of bottom-up). For its goal is a clearly apologetic one, namely the

10 That is, the assumption of the presence of the 'universals' (the general terms or concepts) 'in the (singular) objects', an assumption that is pushed by nominalism into the philosophical junk room.

11 I speak of 'remodelling' because nothing changes in the holism of the real cognitive situation, least of all through nominalism. The remodeling follows only the desire for certitude, based on the idea of the 'self-assurance of the subject' (which is, however, merely a 'performative' one, and immediately becomes interpretative as soon as one connects, for example, the conceptual components of the 'Cogito, ergo sum' with contents. Try to explain to someone what you mean by 'thinking'). 'Certitude' in the intended sense does not presuppose 'universal'- realism, but an immediate 'universal'-presentism (in an act of perception or thinking). It is per se (in accordance with the 'naïve' understanding of cognition) a passive concept, but linked to activity, and therefore naturally accessible to infinite reflection (see the topos of 'givenness').

12 The strength of this power of suggestion is demonstrated by the example of Quine, who even after abandoning the primacy of epistemology for reasons of his theoretical 'epistemological holism' still sticks to the linear model of cognition instead of consequently taking the holism of the real cognitive situation as the initial basis for the reflection on cognition as a real process (and thereby questioning the paradigms of epistemology).

13 As Carnap writes: „Man pflegt in der Erkenntnistheorie zu sagen, daß die ersten Sätze sich auf 'das Gegebene' beziehen; es besteht aber keine Übereinstimmung, was als das Gegebene anzusprechen ist.“ (Carnap, R. (2004), p. 85. [Translation:] "In epistemology, it is customary to say that the first sentences refer to 'the given'; but there is no agreement as to what is to be addressed as the given.“)

epistemological justification of the universal claim to validity of the 'physical laws' on an empirical basis. But this claim is (foremost) a normative one, and not (merely) a descriptive one. This results in considerable problems, but the 'description' as a foundation (on which the 'induction' is then built) is not questioned.

In his influential work 'The Empirical Stance' (to which I refer in the following), Bas van Fraassen for example describes what he regards as the hallmark of science, namely 'objectifying inquiry', by the following features: „A science, or a research project within a science, has a domain. It is tempting to think of its initial delimiting as specifying a set of things. … [But] it is more accurate to delimit such a domain in terms of the quantities or parameters allowed to figure in the description of the phenomena to be studied. Under quantities I include properties and relations.“[14] And then: „So the first step in setting up the scientific inquiry is to select the 'relevant' quantities. … The paradigm example of this procedure was Galileo's list of primary qualities for physics. Physical description was to proceed solely in terms of these qualities; no others were to be admitted.“[15]

The fundamental point that is important here is the word 'description', which in my view represents a fundamental misunderstanding. For the 'quantities or parameters' mentioned do not serve physics to describe things, but rather to substitute (or replace) them on behalf of the heuristic aim or purpose. The cognitive concept of physics is fundamentally different from that of metaphysics. It is neither descriptive nor object-related, but rather transcendental and generalizing. The starting point is not the observation of the behaviour of objects as such, but the question or research into the reason for this behaviour. Physics is guided by its heuristics, by the aim of establishing the reason for the behaviour of objects by establishing exact correlations between the objects and their behaviour, mathematically, in the form of quantity equations. 'Bedingungsverhältnisse' ('conditional relations') is what classical physics is all about,[16] and it tries to trace them by assuming transcendental concepts (physical base quantities), that span across all individual objects. Physics substitutes 'relevant quantities' (the relevant 'parameters') for the objects in a heuristic context.[17] In this sense, also van Fraassen writes at one point: "As we saw, identifying a domain of inquiry takes in general the form of specifying a set of 'relevant' parameters instead of things."[18] This insight into the (heuristically guided) transcendental cognitive approach in physics is, however, usually completely overlaid by the adherence to the descriptive ('metaphysical') concept of cognition and the linear subject-object model of cognition.

For although van Fraassen wants empiricism no longer to be understood in the classical epistemological sense of assumptions ('dogma or doctrine') about the foundations and structure of cognition (as "construction of a ... theory of the processes of cognition")[19] , but as "stance (attitude, commitment, approach . ...)",[20] in the sense of an 'undogmatic attitude', analogous to that of science ("The very spirit of empirical science is the antithesis of dogmatism"),[21] this does not change the

14 Van Fraassen, B. C. (2002), p. 160. Galileo's list comprises: number, figure, magnitude, position, and motion.

15 Van Fraassen, B. C. (2002), p. 162

16 © Carnap, R. (1926), p. 10f. (Carnap, however, interprets these 'conditional relations', according to the object-related thinking, merely functionally, in a basically singular way). The objects as such do not interest physics at all. By the way, the metaphysical, object-related concept of cognition is also a heuristic concept, which corresponds to the naïve concept of cognition, and for this reason does not appear as a form of heuristics at all. This heuristic follows the logic of the 'What is ...?'-question. But the problem metaphysics encounters is that there is no 'absolute determination', that everything and anything is only ever determined in relation to something else. Which, by the way, is the departure point of its 'speculation'.

17 The difference between 'quantity' and 'parameter' corresponds, by the way, to the difference between (measurable) 'property' and 'transcendental concept', i.e. between 'expansion' as a 'property' of a specific object, and 'expansion' as a 'cross-object concept' in a heuristic context. But only insofar as a parameter heuristically leads to or contributes to the discovery of exact conditional relations (in the form of quantity equations), it is a 'relevant' (effective) parameter.

18 Van Fraassen, B. C. (2002), p. 190

19 Van Fraassen, B. C. (2002), p. 77

20 Van Fraassen, B. C. (2002), p. 47

21 Van Fraassen, B. C. (2002), p. 44

adherence to the whole set of paradigms of epistemology.[22] Accordingly, he views 'science' in general from the point of view of 'objectivity': "Scientific inqiry is an objectifying procedure "[23] 'Science' thus embodies the 'empirical stance' by refining this 'undogmatic' attitude into an 'objectifying procedure'.

The consequence of this procedural conception of science from the point of view of physics is that its heuristics, its specific (inquiring, not descriptive) approach to things, is simply attributed to 'undogmatics' (the empirical attitude, the scientific 'method').[24] The ontological premises of the naïve understanding of cognition (which are also those of metaphysics and epistemology) thus continue to dictate the (in)comprehension of physics, the transcendental, ontological dimension of its heuristics ends up epistemologically 'off'. Thus van Fraassen himself explicitly writes: "We must distinguish Galileo's requirement as methodological discipline from his insistence that these are the basic parameters of reality. The methodological requirement shaped modern science even while the list of 'primary qualities' kept changing."[25]

The misunderstanding is that Galileo's 'list of primary qualities' is understood from a purely methodological point of view (as a 'methodological requirement') - in the sense of a certain selection of 'properties' of the objects that are allowed for their 'objective description' with respect to the phenomena -, and that this procedure (in accordance with the object-related concept of cognition) is interpreted in the sense of an objective statement about the things (which turns out to be 'untrue' by the subsequent development of physics). But a completely different view is obtained if one sees Galileo's 'list of primary qualities' as 'parameters' with which physics 'gets to grips' with the things, as concepts that transcend the individual things, on the basis of which it analyses their behaviour, and in doing so (by means of discovering quantity equations) successively deprives the individual things of their alleged autonomy. Galileo's insistence does not have the sense of a statement that is to be qualified as true or untrue in itself, but rather that of a programmatic statement that must be fulfilled (through research). The successive change of the relevant parameters in the course of the progress of physics does not have the character of a refutation of earlier statements, because the yardstick of their evaluation is not an ominous transcendental reality, but rather the own heuristic claims (the demonstration of conditional relations).[26] Claims that, due to the growing number of phenomena that form the object of physical research, also repeatedly lead to modifications of the relevant parameters, which therefore change with the progress of physics just as much as its 'image (concept) of reality'. This depends on the state of research, and in this sense it will probably never be completely done with.[27]

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22 Even though the justification for the solitary standpoint of the subject vis-à-vis the objects no longer rests on the 'dogmatic' theory of the construction of cognition and the thesis of the self-assurance of the subject, but lies, detached from everything, with the subject as an inescapable and unquestionable 'point of reflection'.

23 Van Fraassen, B. C. (2002), p. 156. And he explicates the meaning of 'objectification' in several ways, as 'objective distancing', 'objective neutralization', and as before, 'objectifying inquiry' (ibid., p. 156ff.), And at another place: „Science is a paradigm of rational inquiry. To take it as such is precisely to take up one of the most central attitudes in the empiricist stance.“ (Ibid., p. 63). This, by the way, leads to all sciences being lumped together (according to the motto 'one size fits all'). The heuristics consequently play only a secondary role, if at all. Thus, for example, it is also stated by van Fraassen: "As I see it, with some minor adjustments the pattern of objectifying inquiry is certainly general enough to include the sciences and in fact all disciplines pursued with academic discipline. (Van Fraassen, B. C. (2002), p. 165)

24 See Van Fraassen, B. C. (2002), p. 159

25 Van Fraassen, B. C. (2002), p. 162

26 This, as we will see later, is also the reason for the certainty of knowledge in physics.

27 By the way, the 'descriptive' view of physics leads itself ad absurdum where 'theoretical entities' are concerned. Also the concept of physics in the sense of 'mere explanation' loses its sense where the explanation fails, as in the case of the well-known quantum theoretical paradoxes. In both cases, mere epistemological reflection (without addressing its 'ontology-ladenness') falls short. The direction of ontological reflection is pointed by physics itself. For the procedure of classical physics successively deprives objects of their autonomy without being able to do without them as points of reference. However, this scenario changes fundamentally once again with the discovery of the electrical and magnetic phenomena. The objects as reference points are thus heuristically removed, they are

But this is not due to the ominous 'transcendence' of reality, but rather the opposite, to the holism of the real cognitive situation, to the fact that the subject itself is part of that reality which it is trying to recognize. The real, holistic cognitive situation excludes certainty from the outset. This has immediate fundamental consequences for epistemology in general. The constructiveness of thought moves to the forefront in comparison to the fundamentally passive (receptive) understanding of cognition in epistemology. This applies not only to the perception of objects, but also to the self-perception of the subject, i.e. the perception of reality as a whole.[28] The concept of reality is therefore not a fixed standard that epistemology could apply to physics; rather, physics itself has a decisive say in this respect.

The central point of my argumentation is therefore that the thesis of the primacy of epistemology (and the paradigms associated with it), which is deeply rooted in modern philosophy, is itself the greatest obstacle to an adequate understanding of the cognitive concept of physics (and to the understanding of its ontological relevance as well as competence).[29] The adequate epistemological understanding of physics must start with its heuristics, and the prerequisite for this is the recognition of the real, holistic cognitive situation.

The topic of the first section will therefore be epistemology, its ontological premises in general, and the (rationale for the) paradigms of epistemology in particular (in confrontation with the real cognitive situation). This serves as preparation for the second section, which deals with the question of an adequate understanding of the transcendental, generalizing cognitive concept of physics in confrontation with the epistemologically based views (and fundamental problems) of the philosophy of science. Finally, the third section deals with the conclusions that can (or must) be drawn from the transcendental concept of 'electric charge' concerning the ontological status of the 'theoretical entities' of microphysics. The discussion there focuses on the confrontation with the position of the so-called 'Ontic structural realism'.

All three sections are designed in such a way that they are understandable in themselves.

1. The 'metaphysical' concept of cognition and the primacy of epistemology

Our naïve understanding of reality comprises, as indicated, two aspects, one of which could be roughly described as 'objective' (perception-based) and the other as 'holistic' (rather experience-based), and whose compatibility in various respects has already caused great problems for classical metaphysics.

The 'objective' understanding of reality is a constitutive element of our idea of cognition. For cognition (and knowledge) always includes an idea of what cognition (and knowledge) is, and this idea consists essentially of nothing other than the idea of the ('mental') relationship to something that exists in a distinct form and an autonomous way, independent of cognition (and knowledge). The concept of autonomous substance with intrinsic 'properties' corresponds to this ontologically. Both concepts, the concept of cognition and the concept of reality, therefore refer to each other.

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ontologically downgraded. The decisive question then concerns the ontological status of the postulated theoretical entities. And for the answer to this question the adequate notion of the cognitive concept of physics is decisive.

28 Also with regard to the understanding of cognition. Van Fraassen himself correctly writes: "There is no way to write a theory of cognition while escaping from our general beliefs about what we and our world are like." (Van Fraassen, B. C. (2002), p. 81). However, he thinks that the reflection on cognition (which of course presupposes a certain model of cognition) is (because it is 'undogmatic', therefore) unaffected by such empirical questions. But we are not only 'thrown into this imperfect, fallen world, ... engaged in an 'enterprise of knowledge'" [ibid., p. 82]), but we are completely part of this world.

29 A certain difficulty that will become apparent, however, is that physics itself, due to the fact that our thinking and our language is very much permeated by the naïve understanding of cognition and the corresponding concept of reality (keyword: 'qualities'), does not usually differentiate in its self-reflection and self-representation according to its actual approach.

Cognition appears to be conceivable no differently than under this ontological premise. Logically, this corresponds to a passive, reception-heavy concept of cognition.

The second, 'holistic' aspect of our naïve understanding of reality, which has nothing to do with the concept of cognition, is the understanding (or experience) of reality as something comprehensive, of which we ourselves are part (as an object among objects), on which we are at the same time highly existentially dependent (and to which we are at the same time at the mercy of). This concept of reality has its roots in our (life) experience, our way of dealing with things and our being affected by events. This second, holistic aspect of 'reality as a whole' is expressed in terms like 'world' or 'nature'.

Another aspect that plays a role in connection with these two aspects of reality is that of the transience of things, the impermanence of their existence. Therefore, one can consider the individual being as the impermanent, which is subject to a constant change, a becoming and passing away, or as the concrete, actually existing, which has a certain degree of continuity and permanence in its specific existence.[30] The actually real is, in one case, the substrate or principle that underlies all change and remains the same in all change ('matter'), and in the other case it is the concretely existing (perceptible), substantive, individual being (or such-being).[31]

These different ontological approaches correspond on the epistemological side to a different evaluation of the relationship between perception and thinking. The naïve, reception-heavy concept of cognition is contrasted in the other case by a concept of cognition that starts out from the primacy of thinking and its principles, and is accompanied by scepticism towards direct perception. It is this current that stands at the beginning of philosophy and the 'scientific questioning' of nature, manifested in the divergent viewpoints and positions of the pre-Socratic philosophers.

Classical metaphysics, on the other hand, assumes a naïve, passive concept of knowledge, object-related, specifying, classifying, based on the (seemingly) 'objective' perception of distinctions (with the support of the mind). The assumption that these distinctions, in the form of general terms (universals), have a direct correspondence 'in the (concrete, individual) things' themselves, is called 'realism about universals'. The individual, concrete being, is thus always at the same time a 'specifically general' one, and in this respect cognition is essentially to be understood in the sense of 'passive reception' (perception). Within this framework, Plato and Aristotle determine the relationship between the concrete individual and the specifically general aspect of beings in different ways, and their views and positions reflect two fundamental problems, both of which lie at the interface of reality and cognition, of ontology and epistemology.

Plato gives ontological priority to the general aspect ('ideas'). For the world in the way we perceive it consists of individual objects of the most diverse kinds, which we recognize by categorizing them, i.e. by assigning general terms ('ideas') to them. The corresponding objects themselves may differ in many ways (e.g. in size, shape and colour etc.) and may also be unstable, but our ideas are completely unaffected by this. Plato concludes from this (in his famous Allegory of the cave) that pure ideas are the true being, and thus the only worthy object of cognition (in the sense of 'contemplation of ideas'). The concrete, sensually perceptible, transient things, on the other hand, are only imperfect (shadowy) images of the true being. Conversely, this means that the character of our perception of things, which is usually not very conclusive in itself and rather circumstantial, is a faithful image of their real, muddled existence that is subject to ongoing changes.

Aristotle, on the other hand, gives ontological priority to the concrete individual, and accordingly assigns universals directly to the concrete existence of things; he supports an ontic realism about universals. But this leads via 'specific generality' to the problem of dialectic. For every term thus (as

30 Transience and permanence, as the phenomenon 'reproduction' shows, can also enter into a certain symbiosis.

31 Ancient atomism occupies a special position in this respect, linking the two views by linking the aspect of the impermanence of the concrete things of our perception with the thesis of concrete (substantial), indivisible and imperishable entities that produce all impermanent things by law, in a synthetic way.

is shown by its definition) refers beyond itself to other, more general terms. This conceptual holism leads (in its strict expression in the form of classification) in the context of ontic 'universal'-realism to a gradual dialectic, in the last consequence ascending to the idea of the 'absolute universal' being, the 'absolute substance'. With this, however, the pillar of the reality concept of classical metaphysics, the autonomy of the individual substance, is shaken.[32] And epistemologically, with this, in addition to perception and understanding, a further 'cognitive faculty' comes into play, the faculty of (rational, 'speculative') reason.

The declaration of perception, understanding and reason as 'cognitive faculties', as a 'quality of man', is, on the one hand, due to the substance-related way of thinking, which can only register or understand the 'dynamic' aspects of reality in general by way of assigning them to the 'concrete', as 'potential' or as 'striving'. On the other hand, however, it is also due to the fact that the assumption of an unambiguous correspondence between 'objective determination' and 'objective perception' under the conditions of the holism of the cognitive situation, from which metaphysics starts, is not 'realiter' (without 'bird's eye view') comprehensible. Cognition is recorded as a simple fact and therefore remains a mystery.

With the doubt of nominalism concerning the notion of reality about universals, epistemology finally comes into its own. For this doubt removes the basis of the naïve, purely passive (receptive) understanding of cognition, and thus for the first time places the question of cognition as a problem in its entirety (in the sense of an activity in its own right) on the agenda of philosophy. However, epistemology from the outset strongly limits the question of cognition by focusing on the mere question of 'certainty'. This means that it fundamentally adheres to the metaphysical (object-related, specifying) concept of cognition, as well as to the fundamentally passive, receptive understanding of cognition. The role of thinking (the 'mind') changes through the (formal) renunciation of the assumption of 'universal'-realism, however, to the effect that its activity is no longer predominantly passive, 'understanding' (classifying), but rather active (categorizing), based on subjective sensory impressions.[33] These are now understood as the content basis and starting material of thinking, and (in the empirical tradition) as the source of certainty, or security of knowledge.[34]

The association of sensory impressions with subjective certitude (unless it is to be limited to the act of perception) presupposes their fundamental unambiguity. This presupposes, on the one hand, the idea of a reality determined ('objectively') independently of thinking, whose 'signals' we try to assemble through thinking to an 'objective' image of reality, and on the other hand, it presupposes or demands the unambiguity of the signals themselves. Here, however, it begins to become somewhat

32 The ontological consequences are most radically expressed in Spinoza. He thinks the thought of the 'absolute universal' being consequently to the end by conceiving all individual beings as mere 'attributes' of the 'one', absolute substance. A kind of metaphysical 'reductionism'. The second big problem of 'speculative' metaphysics, so to speak the 'flip side' of the problem of dialectics, is the question of the possibility of determinacy in itself ('intrinsic qualities'), of distinctiveness without distinction. This is a problem Leibniz focuses on, while Hegel aims at solving both problems.

33 I am speaking here only of the empirical tradition, because rationalism, which is represented above all by Descartes and Leibniz, trusts only the principles of reason. Descartes uses the methodological doubt and the thought figure of 'certitude' basically only to be able to push aside (at a stroke) the metaphysical world view which was dominant at his time (indeed, in its religious expression even the only permissible one), in order to replace it with the cognitive concept of physics (conceived as a research project). This is based on the substitution of the concrete objects by the general concept of the 'res extensa' (as the starting point for the task of a scientific reconstruction of the concrete objects), and in doing so, relying exclusively on one's own mind, whose principles he regards as 'God-given' for reason of (his own?) security. This 'divine assurance' differs fundamentally from the Kantian way of anchoring the categories of understanding in the subject (as a transcendental condition of the possibility of the 'synthesis of sensory impressions'), in that the trust in God can also be doubted, and with it also the principles (categories) of thinking from which we usually start. They are therefore not fundamentally unquestionable, as is the case with Kant.

34 However, this does not say anything about how far this certainty (especially with regard to physical knowledge) 'carries' (see for example David Hume). In some interpretation, with the trust in the 'sensual certainty', or the 'givenness' of the sensory impressions, 'universal'-realism comes in again 'through the back door' (as 'universal'-presentism).

troublesome. At the latest when it is not only about discrete qualities (colours and forms) but also about contents, interpretation comes into play, the unambiguity (without any 'blindly' available interpretation schemes) stops. This means that unambiguity, and thus certainty, is at most accorded to the sensory impressions in such a way that they are understood as 'unambiguous indication', i.e. by semantically assigning an interpretation to them, giving them a meaning, or applying an available grid for screening.[35]

Subjective certitude is therefore not necessarily synonymous with objective knowledge. But it is exactly this association in reverse form, i.e. the association of ('real') knowledge with certitude (behind which in a concealed manner the old realism about universals emerges), by which subjective certitude is elevated by epistemology to the criterion of real knowledge. The desire for certainty is turned into a demand. And insofar as the concept of subjective certitude (as the criterion of legitimation of knowledge) depends on the conception and evaluation of the 'cognitive faculties', epistemology thus slips into the role of 'prima philosophia'.

Behind the epistemological claim of the 'legitimation of knowledge' there is a plethora of different assumptions. Beginning with the ontological premises underlying the naïve understanding of cognition and the corresponding metaphysical concept of cognition (not least the assumption of mutual autonomy), up to the idea of the various 'cognitive faculties', which in turn are underlaid with different constructs (such as 'perception' with 'sensory impressions'), which in turn carry with them different connotations and associations. All this is part of what I would call the 'paradigms of epistemology', and in this respect it is not fundamentally different from 'normal' science. The most momentous paradigm of epistemology, however, arises from the aforementioned association of cognition with certitude, which leads to the real, holistic 'cognitive situation' being reinterpreted (or remodelled) into a linear 'cognitive relationship', into the model of the subject-object relationship. This paradigm is particularly consequential because of the associated 'impossibility of transcending the subject',[36] which makes epistemology the last instance in all questions of knowledge. This is the basis of the 'primacy of epistemology', its claim to the 'legitimation' of knowledge.[37]

In reality, however, this linear relational model of cognition (with its assumption of the strict 'transcendence of objects') represents a complete distortion of the 'real', holistic cognitive situation. This situation is per se open to interpretation because it offers no fixed, unambiguous point of reference, let alone evidence. The 'real', empirical subject perceives itself (reflectively or unreflectively) as part of a whole (its environment, or 'reality'), within the framework of which it only grasps the objects and itself, categorising, analysing and reflecting, with difficulty, without a fixed, unambiguous point of reference, essentially only on the basis of more or less rough schemes.[38] Therefore, the 'empirical subject' has no 'certainty of knowledge', neither with regard to

35 In epistemology, the source of the unambiguity (or even the interpretation) of the signals is completely in the dark, but it takes no notice of this problem. Generally speaking, the real problem of epistemology is that it has never really taken the objections of nominalism to realism about universals seriously. It simply does not ask the question of the source of the content, but limits itself to questioning its certainty. This is also reflected in the fact that she blindly relies on her own operational terminology.
The most interesting thing about epistemology is in general its problems, those it creates through its own paradigms and its own model of cognition, but above all those it does not address, the 'metaphysical' ones (linked to the assumption of autonomy on both sides).

36 The cognitive subject thus becomes a pure (epistemologically non-questionable) instance (strictly separated from all other objects of knowledge, which it therefore faces in absolute transcendence). By the way, this does not apply to Descartes, because he transcends both 'summa genera' ('res extensa' and 'res cogitans') once again with reference to a supreme substance of a common origin (God). In this way he introduces, abstractly seen, a reductionist thought.

37 This paradigm weighs heavily on philosophical reflection on science in general, and poses, as we shall see, a huge obstacle for an adequate understanding of physics in particular.

38 That the holistic cognitive situation is also an existential situation is, by the way, indicated by the schemes themselves. There is little in our environment that is not 'defined' by its use or benefit or effect on us, even the weather or the computer. A more 'objective' picture (as for example in metaphysics) only emerges when the frame of reference is changed (or extended, as the case may be when it is about the coherence of the 'whole', and thus also

the objects nor to itself. Nor does it have any 'certainty of knowledge' with regard to its position within the framework of 'the whole' (as well as the entangled relationships to it and its 'parts'), for the transcendence of objects (as our handling of them shows) is by no means strict.[39] This means that direct perception as such is not 'revelatory', but fundamentally (merely) 'indicative', for which reason the constructive power of thought (the 'mind') is fundamental with regard to any kind of cognition.[40] The fundamentally passive (receptive) conception of cognition of metaphysics and epistemology (which is already expressed in their talk of 'cognitive faculties') is not tenable.[41] Due to the holism of the real cognitive situation, our cognition cannot, in principle, exceed the status of 'interpretation'.[42] This applies not least to our understanding (and conception) of cognition itself. For this is nothing other than an interpretation of our cognitive relationship(s) on the basis of the (scientifically by no means unquestionable) assumption of mutual autonomy (which in turn is the basis and necessary condition for the idea of 'certainty').

With regard to the philosophy of science, it is first of all essential that the argument for interpreting the real, holistic cognitive situation in terms of a linear cognitive relationship rests solely on the desire for certainty or on the assertion of certainty as the key criterion of 'real' knowledge, assuming that certainty is a real option (which in reality is excluded from the outset by the holism of the situation, for even the epistemological concepts themselves are nothing more than interpretations of the cognitive situation in which we find ourselves). It is the enduring merit of neo-positivism to have destroyed the basis of this argument by the demonstrative failure of its apologetic intention to declare certainty to be a criterion of scientificity.[43] This failure basically allows only one conclusion, namely the abandonment of the demand of certainty as the measure of knowledge, and thus also the turning away from the linear relational model of cognition (as a methodological implication), and consequently the acceptance of the real, holistic cognitive situation as the basis of epistemological reflection. With regard to the theory of science, this conclusion means, first of all, nothing else but to abandon the epistemological claim of 'legitimation' in relation to physics and to turn to an unbiased reflection of physics' cognitive concept (alias heuristics).[44]

The conclusion that the subsequent theory of science drew on the challenge posed by the failure of the neopositivist approach was, as is well known, a different one. Namely, the adherence to the ideal of certainty and to the linear relational model of cognition, but with an undertone of resignation (in the sense of questioning or limiting the claim of physics to real knowledge).

The paradox of philosophy of science basically consists in the fact that it does not apply the thesis of the hypothetical status of scientific theories, which it propagates itself, to 'epistemology', i.e. its

about the interpretation of ourselves). By the way, the reference of our usual schemata (as a grid of perception) to use or utility reminds us of the meaning of the term 'reception' in biology.

39 Cognition is just one out of a spectrum of manifold (mostly pragmatic) relations of the subject to its surrounding objects. If one (scientifically) assumes the opposite of strict transcendence, namely total immanence (as the basic physical state), then it can be stated that (the genesis of) self-consciousness is the necessary condition of the possibility of distinguishing anything 'from oneself' (i.e. for the notion of transcendence, yet not a strict transzendentalpragmatisch is only due to the demand of 'certainty').

40 Think, for example, of watching a game! In this point there is of course a proximity to rationalism.

41 But since it is at the same time a basic feature of our 'lived experience' it cannot be dismissed. Any future theory of cognition on a scientific basis will therefore ultimately have to deal with it.

42 The interpretation is usually 'supported' by semantic conventions. Only in contrast to this, the meaning and scope of the cognitive concept of physics will be fully understood!

43 In a short essay entitled "The Epistemological Paradigm of Philosophy of Science" I already pointed out some time ago that basically the entire (subsequent) development of philosophy of science cannot be interpreted otherwise than as a deconstruction of the basic 'ideal' paradigm of epistemology, the idea of certainty as the measure of 'real' knowledge.

44 Quine does indeed take the step of 'abandoning the goal of a first philosophy' (Quine, W. V. O. (1981), p. 72), but without questioning the paradigms of epistemology itself. He therefore justifies his leap to 'naturalism' in a purely decisionist way when he writes: "The other negative source of naturalism is unregenerate realism, the robust state of mind of the natural scientist who has never felt any qualms beyond the negotiable uncertainties internal to science." (ibid.). His 'naturalism' propagates a belief in science that is not covered by the philosophy of science.

own foundation (which would be tantamount to a direct recognition of the real cognitive situation) but rather (unimpressed by its own insights, which speak for such a recognition) adheres to the primacy of epistemology.[45] This adherence also leads to the fact that the theory of science not only asserts the epistemological, but ('by virtue of' the ontological premises of epistemology) implicitly also the ontological souvereignity of interpretation over the findings of physics, while the latter is conversely on the point of (gradually) dismantling no less than the ontological premise of epistemology, namely the objective understanding of reality.

All in all, this speaks less for the scientific soundness of epistemology than for its power of suggestion.[46] This is not least due to the fact that every form of cognitive activity (including physics) has always implicitly presupposed a certain understanding of cognition, but we have so far had no other understanding of cognition than the 'naïve' one (with its 'theoretical' underpinnings). It makes a difference, however, whether one provisionally assumes a certain understanding of cognition (for lack of alternatives available so far), i.e. takes it (with reservations or simply unreflected) as a starting point, or as a firm foundation, as is the case in philosophy of science.

The acceptance of the real, holistic cognitive situation as the basis and starting point of epistemological reflection forces us to look at physics' heuristic approach, its specific cognitive concept, in an unbiased way, or rather uninfluenced by the paradigms (and 'ideals') of epistemology. But I would like to start from the two cornerstones of the heuristic approach of philosophy of science to physics, namely its two basic problems, the problem of demarcation and the problem of induction.

2. The physical concept of cognition

The so-called 'demarcation problem', namely the question of a reliable criterion for the demarcation of empirical science, particularly physics, from metaphysics,[47] forms the historical starting point of philosophy of science, which brings out its methodological approach. What is remarkable about the question is that it already openly expresses in its formulation that the philosophy of science sees no difference between metaphysics and physics in terms of its concepts of knowledge. It is, in other words, the complete ignorance of the fundamental difference between the heuristic approaches of metaphysics and physics, in short, the difference between the question 'What is x?' and the question 'What is the reason for the behaviour of x?' (a point that can only be explained by the unreflected adherence to the naïve understanding of cognition and the paradigms of traditional epistemology). The 'longed-for' demarcation is thus only about the supposed role of empirical evidence in connection with the topic of the 'certainty of scientific knowledge'. The two criteria 'verifiability' or 'falsifiability', brought into play by Neopositivism and Critical Rationalism, thus reflect, in a top-down-perspective, two different views on the role of empirical evidence concerning the scientific status of the theories.

The difference between the two criteria can be explained by the different attitude towards the question of induction. Neo-positivism assumes that empirical science follows the path of induction (through the 'inductive method') from observation to its theories. The idea of induction is based on the assumption that there is a logical bridge between observation and theory, namely the 'proof by induction', that theory formation is therefore a rationally comprehensible process. Critical rationalism disputes this assumption.

45 Incidentally, this behaviour becomes completely inconsistent when philosophers of science take a stand on questions of the philosophy of mind, thereby expressing confidence in a future explanation of the 'phenomenon of cognition' by the empirical sciences.

46 The deficit of 'scientific substantiation' is usually compensated by authority, by the referencing of 'great names'.

47 In Karl Popper's formulation: "The problem of finding a criterion which would enable us to distinguish between the empirical sciences on the one hand, and mathematics and logic as well as 'metaphysical' systems on the other, I call the *problem of demarcation*. (Popper, K. R. (2002), p. 11)

The notion of induction, of inference from the individual (i.e. individual experience or observation) to the general (a statement with a general claim to validity), belongs to the standard inventory of the empirical conception of cognition. The idea is plausible (think of the popular example of the phrase 'All swans are white'), but encounters two problems in physics. The first problem is that physical statements are usually of a 'law-like' character ('laws of nature'), which make a normative claim to general validity that cannot be logically justified by mere generalisation. This is the real 'induction problem'. But there is a second problem linked to it, which consists in the fact that physical statements seem to have something like 'causal links' as their subject, the observability of which seems doubtful even prima vista. As David Hume writes: "When we look about us towards external objects, and consider the operation of causes, we are never able, in a single instance, to discover any power or necessary connection; any quality, which binds the effect to the cause, and renders the one an infallible consequence of the other. We only find, that the one does actually, in fact, follow the other."[48] The necessity of the connection can indeed never be deduced from mere observation, so that in the case of physics the inductive inference is weak from the outset.[49]

With regard to the inductive reasoning, however, the question generally arises as to what is actually being 'generalized' in the observations. The object of the observations are obviously individual objects, their properties and their (dynamic) relations and effects. What does the generalization refer to at all? The usual view is obviously that generalization (by way of theory-building) refers directly to the observation of the 'connection' between the object (with its properties) and the effect. Thus, this view short-circuits the observation via 'generalization' directly with the theory. In this form, the "difficulties of induction logic", as Karl Popper writes, are in fact "insurmountable".[50] He therefore states that "the inference to theories, from singular statements which are 'verified by experience' … is logically inadmissible. Theories are, therefore, *never* empirically verifiable."[51] And he draws the further conclusion from this: "The act of conceiving or inventing a theory, seems to me neither to call for logical analysis nor to be susceptible of it.“ He subsequently assigns „the question how it happens that a new idea occurs to a man"[52] as a subject (with reference to Kant) to the mere 'empirical psychology',[53] whereas "the task of the logic of knowledge … consists solely in investigating the methods employed in those systematic tests to which every new idea must be subjected if it is to be seriously entertained."[54] Popper's suggestion concerning the method mentioned consists in the "deductive testing of theories", the derivation of empirically verifiable statements "from a new idea, put up tentatively, and not yet justified in any way – an anticipation, a hypothesis, a theoretical system, or what you will … ".[55] His answer concerning the 'problem of demarcation' (i.e. the question of a criterion for distinguishing between merely 'speculative metaphysics' and 'empirical science') accordingly consists in the propagation of the criterion of 'falsifiability'. For "statements, or systems of statements, convey information about the empirical

48 Hume, D. (1975), p. 63

49 In order to justify the mental establishment of a causal link itself inductively, i.e. through repeated observation, „we should have“, as Karl Popper writes, "to assume an inductive principle of a higher order; and so on". This „must lead to an infinite regress". (Popper, K. R. (2002), p. 5). A strict and universal determinism cannot be justified on such a basis. The belief in it must have another root.

50 Popper, K. R. (2002), p. 6

51 Popper, K. R. (2002), p. 18. Whereby his definition of 'theory' is quite unspecific: "Scientific theories are universal statements.“ (Ibid., p. 37)

52 Popper, K. R. (2002), p. 7. See Popper's instructive and detailed criticism of "the assertion that Newton's theory was derived from observation", in the essay. "On the status of science and of metaphysics" (in: Popper, K. R. (1978), p. 184ff.)

53 The reduction of Kant's 'transcendental logic' to mere 'empirical psychology' naturally also contains a point against Kant.

54 Popper, K. R. (2002), p. 8. In this connection one speaks of the separation of 'discovery context' (or 'context of origin') and 'justification context'.

55 Popper, K. R. (2002), p. 9

world only if they are capable of clashing with experience".[56] The 'real' reference of the theories to transcendent reality is thus not rationally comprehensible and justifiable, but only 'unilaterally decideable', via double negation. For the significance of a possible 'confirmation' of the theory by an experiment (by means of the deduction of empirically verifiable statements) logically consists only in the proof of 'non-failure' (which can be interpreted in a vague form as an 'approach to the truth').

However, I believe that Popper is throwing in the towel of the rational justifiability of physical theories too soon, and this is because his position is directed towards the solution of the induction problem. The way this problem is presented (namely in the form of a short-circuit of the observation via 'generalization' with the theory)[57] leaves, as far as physics is concerned, one essential point out of consideration. For physics' approach is not based on the observations per se (as an 'empirical foundation'), nor does it simply make generalizations, but rather pays attention first (as a first 'methodological' step) to the comparability of the observations.[58] But this step of establishing comparability does not take place aimlessly.

For neither the observations as such, nor this methodological step is the actual starting point of her theory formation, but her heuristic approach to the objects (or the questions she poses to 'nature'). The object of the observations are, as mentioned above, individual objects, their properties and their (dynamic) relations and effects. In contrast to metaphysics, however, physics does not focus on the objects themselves, but on their behaviour, i.e. on their (dynamic) relationships and effects. Physics is not concerned with the individual objects as such, but rather with the question of the reason for, and (in connection therewith) the regularity of, their dynamic behaviour. The aim is not to describe the objects but to state the reasons for their behaviour.

The cognitive concept of physics, its heuristic approach to objects, consists generally in reasoning about the behaviour of objects, by way of attempting to uncover regularities, in the sense of exact correlations, between objects 'in general' and their dynamic behaviour.[59] The relation of physics to objects is therefore an indirect one. The specific cognitive concept of physics (its heuristic approach) is thus, in clear contrast to metaphysics, not object-related, specifying (by way of differentiation and categorization), but transcendental and generalizing.[60]

The transcendental heuristic approach is expressed in the general consideration of the dynamic relationships and effects of objects as 'phenomena'. This qualification documents the scientific claim to explanation in a general sense that goes beyond the 'causal explanation' of the individual case.[61] And it also documents the fact that the 'meaning' of observation in the context of physics is

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56 Popper, K. R. (2002), p. 315. On the following page it says: "One might therefore characterize the empirical sciences as follows: In so far as a scientific statement speaks about reality, it must be falsifiable: and in so far as it is not falsifiable, it does not speak about reality."

57 This form of generalization essentially corresponds to the method of metaphysics, namely subsumption on the basis of analogy formation. See its explanation of the behaviour of objects in terms of 'striving'. The concept of 'causality' as a 'principle of explanation' plays a similar role, and corresponds (or owes) to the 'metaphysical' (object-related) cognitive concept of epistemology.

58 From this point of view Popper replaces the short-circuit of theory with observation only too quickly with the short-circuit with intuition.

59 Significant for the epistemological interpretation of the role of heuristics in relation to physics seems to me the description by van Fraassen, who, following a quotation from Kant in this regard, writes: "I cannot emphasize this too much: ... these forms of objectification in science ... are among the very keys to success of our modern science." (Van Fraassen, B. C. (2002), p. 159). Hence, the establishment of correlations is recorded under 'objectification', and thus immediately classified in the scheme 'transcendence' and 'description'. Directly below, by the way, van Fraassen speaks of the 'relativity revolution' which already started with ancient astronomy.

60 The term 'transcendental' is of course (contrary to the Kantian understanding) to be understood in a subject-independent sense. Transcendental (physical) concepts are simply such which serve a heuristic purpose or are of heuristic origin. For physics does not take the phenomena it deals with at face value, as metaphysics does.

61 In this sense, physics' claim to explanation transcends the mere causal principle, since this is a purely heuristic principle that can be combined with any kind of explanation, including teleological, animistic, religious-fatalistic

limited to its indicative status.[62]

The key to an adequate epistemological understanding of physics, however, lies - as the induction problem makes clear - in the topic of generalization. The key point here is, in short, that generalization is not only the goal but also the means of theory building. In other words, it is not the generalization of direct observations that leads (in logically unjustifiable ways, via induction or intuition) from observation to theory, but rather generalization itself has a fundamental role to play in theory building. It is in a peculiar way an essential factor and core component of theory construction. This is in the sense of a (presumptive) substitution of individual objects by transcendental concepts, in an (exclusively) heuristic context.[63] This approach methodically serves to reduce the factor contingency (in view of the infinite variety of objects) as a basis for the discovery of regularities.[64] And this is initially within the framework of the 'modular, factorial analysis' of behaviour, by way of quantification and comparison on an experimental level.

The starting point of the analysis is to establish the comparability of the phenomena in question, to 'parameterise' them, and to do so (according to their dynamic character) in a conditional way (e.g. by observing the behaviour of different objects under the same conditions, or the same objects under variable conditions, or by attempting to evocate an effect under controlled, variable conditions, etc.). By this approach, the individual dynamic behaviour ('the effect') indirectly becomes a 'conditionally prepared phenomenon' on which the modular, factorial analysis of the conditional relationships is specifically based. The analytical role of the experiment in this tentative stage of theory construction consists in the 'preparation' and investigation of the behaviour by means of the assumption of concepts that span ('transcend') the single objects.[65] In other words, it serves to goal of concept-finding, and only in the second instance to confirm or refute the theory.

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etc. explanations, (depending on the 'world view'). It thus refers to that level of (interpretation of) reality which is not specified by the causal principle as such. It rather gives it a new, scientific foundation, based on the investigation of conditional relationships.

62 This is by no means exceptional, but is fully in line with the way we often apply the causal principle in everyday life, for example when we 'hear footsteps' and infer the presence of someone else (perhaps even someone specific) even before we have seen him. We interpret perception 'automatically' as an indication. This means that the 'evidence' of perception (the mere noise) is indirectly transferred to its interpretation. The mediating role in relation to interpretation is played in this case by 'experience'. The interpretation of perception as an indication is, by the way, a basic feature of our relationship to reality (which has to do with its existential character). It pervades our thinking to such an extent that we no longer notice it, because it is related to 'situatedness', which also decides which perceptions we attach relevance to or pay attention to. This role is played in physics by the heuristic approach, which puts the conventional 'grid of experience' itself at our disposal.

63 This is important and otherwise (due to the subject-relatedness of our imaginative thinking) easily leads to a (wrong) identification of transcendental concepts (like Galileo's 'list of primary qualities' or Descartes' general concept of 'res extensa') with 'properties'. But these concepts serve for 'indexing', not for 'description'. By the way, all this refers to classical physics. The situation changes fundamentally at the level of microphysics, where objects are completely removed from the game and precisely defined (by concepts) entities take their place.

64 This approach has more in common with formal (mathematical) class formation than with induction. Formal class formation differs from categorization or classification in that it is not object-related, not specifying. I refer here to Katherine Brading's description of Newton's approach, where she also quotes Newton's "Rule 3 of Reasoning": "Those qualities of bodies that cannot be intended and remitted and that belong to all bodies on which experiments can be made should be taken as qualities of all bodies universally. (Brading, K. (2017), p. 18). This is the basis of the ability to predict.

65 A circumstance that complicates the project of physics and its experimental approach is of course the necessary consideration of possible different (often not directly recognizable) influencing factors, i.e. the analysis of the 'conditions' in a holistic context that requires the development of difficult strategies. Therefore, axioms and models etc. are among the tools of cognition in physics, but I will leave that out here. See for example Katherine Brading, who writes about Newton's approach: "Newton's Principia ... opens with a series of definitions of the terms he will use, including "quantity of matter", "quantity of motion", "inherent force of matter", and so forth. "Immediately following these definitions he turns his attention to time, space, place, and motion." (Brading, K., (2017), p. 15). The actual subject of her insightful article is the distinctions Newton makes with respect to the concept of time: "Thus, Newton is explicit in applying to time the three distinctions of absolute versus relative, true versus apparent, and mathematical versus common. What does he mean by these distinctions, and why do they matter? (ibid., p. 15)

With regard to the epistemological status of physical concepts (and also the ontological assessment of the 'presumptive substitution' of objects by concepts), it is of fundamental importance to include the real, holistic cognitive situation and its openness to interpretation (also with regard to ontological concepts) in the calculation. This is due to the fact that the transcendental concepts are not merely 'subjective' (in the Kantian sense), but rather (regardless of their origin in the subject) subject-unbound, i.e. their only binding is that to the 'lawful' explanation of the phenomena.[66] They are therefore considered ontologically by physics as what is actually 'real', without completely displacing the individual objects, since their substitution by the concepts is not a complete one (it does not include all 'properties'). The substitution of objects by transcendental, object-spanning concepts therefore has the character of an (increasing) 'reduction' from an ontological point of view.[67] From a substance-ontological point of view, this substitution presents itself as an (increasing) withdrawal of autonomy (which has its expression in the normative character of the 'laws of nature').

This transcendental substitution of objects by physical concepts is difficult to comprehend for two related reasons. The first reason is that the reference of the concepts to the objects is, as already mentioned, only indirect (by way of the aim of the generalizing explanation of their behaviour),[68] and the substitution is accordingly a heuristically motivated, successive process. The main reason, however, is the prevalence of the object-related (metaphysical) concept of cognition, which is based on the ontological concept of substance and properties, and which tempts us (almost unavoidably) to think of physical concepts in terms of 'properties' (and of 'theoretical terms' referring to them).

The comprehension of the methodical step of substituting objects by transcendental concepts is in my opinion of crucial importance for an adequate understanding of the cognitive concept of physics in all its facets. Therefore, I would like to deal briefly with the most important ones in the following.

a) Characteristic for the (experimental) cognitive concept of physics is the presumptive status of the transcendental (physical) concepts through their logical connection to the explanatory context. The respective 'generalisation' (by way of substituting the objects by the concepts) is for this reason also immune to doubts of a general nature (à la induction problem), since it is related to the claim and context of reasoning, and therefore a doubt about the concepts must also be justified. Such a justified doubt can, in individual cases (always with reference to the phenomena), take the form of a refutation (a 'falsification'), and thus usually leads to a modification or even to fundamental adjustments.[69] In addition, the concepts of physics themselves contribute to the 'discovery of phenomena', which in extreme cases can call themselves (or connected concepts) into question.[70] In this sense, 'reasoning doubt' is practically 'system-immanent', not least due to the fact that the behaviour of objects has many different aspects, and thus the question arises again and again (according to the 'logic of substitution') how these behaviours are connected, which in turn can be

66 The real, holistic cognitive situation, insofar as it is itself exposed to interpretation by cognition, does not provide any other criterion of truth than that given by the heuristic objective. In the case of physics this is the success of explanation. Further demands, such as 'verification' or 'certainty', are based on a different concept of cognition (a different heuristic) and a certain interpretation of the cognitive relationship (in the sense of absolute transcendence of the objects, which assumption is unique to epistemology and not suitable for physics). On the other hand, it is the demand of certainty itself that 'generates' absolute transcendence. See radical skepticism.

67 In this respect, however, one usually speaks of 'abstraction', but that is not the point, because it corresponds to an object-related (or object-fixed) understanding of cognition, which is successively undermined by physics, as I am trying to show.

68 Thus, for example, the physical concept of 'mass', to which the basic physical quantity 'weight' is assigned, cannot be independently defined or determined, and therefore, strictly speaking, cannot be understood as an autonomous 'property' of an object. (See also: Weizsäcker, C. F. v. (2004), p. 139f.)

69 In this way Stanford's 'unconceived alternatives' can of course also come into play.

70 Such an extreme case is, for example, the concept of 'dark matter', which casts doubt on the universal claim of the 'ancestral' concepts of physics, but is justified by the connection with the grounding of certain phenomena whose 'discovery' is itself based on the ancestral concepts.

an impetus for the revision of existing concepts.

It is this binding to the explanatory context, the presumptive status of their concepts, that guarantees the certainty of cognition of physics. The hallmark of physics in terms of certainty of knowledge is not evidence (qua immediacy of observation) but, on the contrary, reviseability on behalf of reasoning doubt.[71] In this respect, the presumptive status of the concepts mirrors our real cognitive situation and its openness to interpretation.

However, this is only one part of the story, the other part of which is indeed related to observation, not as an 'empirical foundation' with the claim to immediate certainty (i.e. in a grounding function), but with its role as a provider of evidence in the course of concept finding and theory building, or in the course of experimental testing of the theory.

b) Experiment and theory building. The object-spanning (general) concepts are at the service of theory building and form its pivotal point, in terms of the heuristic goal of explaining the behaviour of the objects by way of finding (establishing) exact correlations between the objects (represented by the concepts) and the phenomena. Thus, concept-finding is itself an integral part of theory building; it forms the logical hinge between the theory and the phenomena; empirically by way of (initially tentative) demonstration through experiment. Conceptualization forms the heuristic reference point for the setting of the experiment, it is heuristically an integral aspect of the 'conditional' preparation of the behaviour of the objects, both in the initial design of the experiment and in its further analysis. It is guided by hypothetical theoretical assumptions, by suppositions, 'intuitions', which in turn rely on the transcendental cognitive concept of physics. These close entanglements characterize the tentative, experimental approach of physics, in which 'speculation' and observation go hand in hand. If the inductive reasoning plays a role in this framework, it is in connection with the initial intuition, and with regard to the conclusions to be drawn from the experiment (i.e. in an analytical, not in a reasoning function).

What is decisive is that all these components together, in their coordination with each other, constitute the 'rational method' of physical theory building. However, their rationality can only be grasped if one starts from the real, holistic cognitive situation and the specific heuristic cognitive concept of physics. The attempt to reconstruct this experimental, non-linear methodical procedure and its specific form of rationality on the basis of a completely different setting, namely under the supposition of a linear relational model of cognition, whose input-output logic depends from front to back on the criterion of certainty, is logically doomed to failure. The inductive short-circuit of the observation with the theory is just as much an expression of this failure as the refuge in the black box of 'intuition' as the quintessence of theory building, and (as a logical consequence of this capitulation of the 'ratio') the criterion of 'falsifiability'.[72]

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71 The idea of the certainty of knowledge in physics has, by the way, always been fed more by its exactness and its (seemingly 'regulated') progress of knowledge than by the idea of real evidence. The resounding association with certainty is exclusively due to the paradigms of traditional epistemology. Popper's criterion of 'falsifiability' also hinges indirectly on the idea of certainty of direct observation.
The fascinating thing about Neopositivism is that, in contrast to Critical Rationalism, it also attempts to understand theory building rationally, and in doing so it presumes a fundamental understanding of the transcendental cognitive approach of physics - as, for example, when Carnap writes: „Wir haben gesehen, dass die physikalischen Aussagen Aussagen über Bedingungsverhältnisse sind.“ (Carnap, R. (1926), p. 10. ["We have seen that the physical statements are statements about conditional relationships."]) - but attempts to place this epistemologically within the corset of epistemology and its object-related cognitive concept. For example, when Carnap remarks there „Die Messung von Qualitäten“ sei „nichts anderes als eine besondere Art der Benennung“. (Ibid., p. 61 ["The measurement of qualities" is "nothing else but a special kind of naming".]). Carnap's little book with the title 'Physikalische Begriffsbildung' has almost textbook character in this respect.

72 One can be of the opinion that it is generally this setting, the ('epistemologically motivated') withdrawal of the 'autonomous' subject from the holistic cognitive situation, that forms the basis of almost all problems of epistemology. This, I think, also applies to the epistemological attempts to justify our conviction of the validity ('a priori') of the causal principle, i.e. the "proposition that every change must have a cause" (also des „Satz[es], dass jede Veränderung eine Ursache haben müsse“. Kant, I. (1975), p. 47). For it is basically not difficult to find a 'real-

The success of theory building is based on the adequacy of the concepts. It is therefore these concepts that are indirectly put to the test in experiments. The purpose of the experiment (in the form of the corresponding setting) is therefore to test the theoretical assumptions, which corresponds to 'indirect verification' (in the heuristic context), a type of verification that does not and never excludes revision or modification in all facets (including substitution, limitation or desertion).[73] This indirectness of verification corresponds to the indicative character or status of the observation, its 'theory-ladenness'.[74]

Theory building, concept finding and experiment (under the auspices of the heuristic approach) cannot (and in no phase) be separated from each other.[75] In our attempt to rationally reconstruct the physical approach to things, however, one essential factor of the certainty of knowledge in physics is still missing, which (in the form of the term 'exactitude') has already been mentioned indirectly, namely quantification. It is quantification that, in this network of theory building, concept-finding and experiment, corresponds most closely to the idea and the claim of direct (unambiguous) reference and certainty, namely in the form of measurement.

c) Quantification is the concrete way of implementing (and therefore in the end also the manifestation) of the transcendental, generalizing cognitive concept of physics, in the form of the substitution of objects by parameters or measurement results.[76] Quantification per se represents that radical, object-related generalization, which in the heuristic setting cannot be understood otherwise than as presumptive substitution. The measured values 'represent' the objects (regardless of their other properties), the objects become mere instances, definite values of variables.[77] The function and meaning of quantification, and thus also the fundamental role of mathematics and its central position within the framework of physics, can only be adequately understood in connection with the transcendental, generalizing cognitive concept of physics.[78]

The differentiation of the objects is exclusively based on the measurement. Although this is of an 'objective' character, since the standards are based on convention, i.e. are arbitrary in character, only

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logical' justification for this, if one includes our physical existence. For all our actions, every single movement, and this from our first breath on, is penetrated in an elementary way (and at the same time enabled by) the fact that we are embedded in a real context of interrelations and conditional interdepence. Even our physique, every single muscle, is a 'result' of being embedded in (and existentially dependent on) this comprehensive conditional context. The idea of 'causality' is an expression of the substantiation of a purely conditional relationship, the interpretation of 'conditional relationships' ('Bedingungsverhältnisse') as 'effect relationships' (Wirkungsverhältnisse'). (See Carnap, R. (1926), p. 10ff.). The ontological background is the idea of the autonomy (the 'unconditionality') of substance.

73 A further aspect of the dense network of theory building, concept finding and experiment mentioned above is that already existing theories (as a presumptive part of the solution) can in turn take on (or maintain) a concept function (or concept status) in relation to further phenomena. This in turn is an additional aspect of 'indirect verification', similar to a puzzle. Radical upheavals, 'paradigm shifts', are by no means excluded, because the interpretation of the phenomena has the last word according to the cognitive situation. The rational continuity of physics as a science (of its 'progress of knowledge') results, with regard to the presumptive status of the concepts, from the comprehensibility of the context of reasoning to which the concepts owe their existence, even those that were later rejected (for reasons). Kuhns' thesis of 'incommensurability' is based on the understanding of transcendental, physical concepts in the sense of metaphysical terms (which refer to transcendent objects in a descriptive mode).

74 Not the 'theory-ladenness' of observation is therefore the real problem when it comes to an adequate understanding of the 'physical method', but rather the 'ontology-ladenness' of epistemology!

75 In the case of relativity theory, of course, theory building refers to the already existing concepts of classical physics (space, time, velocity, mass / respectively speed, mass and energy) and their interdependence, but it is also based on (in this case purely mental) experiments that directly involve the observer (the 'subject'), i.e. are not conceivable without the real, holistic cognitive situation! Since it refers directly to the transcendental conceptual level, the corresponding indications, in the form of observable effects, are also extremely 'theory-laden'.

76 The connection of the transcendental concepts with the physical base quantities, the question of 'reference', is the subject of the next point.

77 This circumstance of variability in connection with the accuracy of the measurement, the arbitrary scalability, has great importance with regard to the confirmation of the general validity of the theory in experiment.

78 From the point of view of the ('metaphysical') object-related cognitive concept, the role of mathematics in relation to physics (its 'applicability') basically appears as a puzzling fact, almost like a strange coincidence.

the relation remains as an absolute (in the strict sense of objective) value. This is independent of the scale. This is also true when it comes to the relationship between the measured values of different basic quantities (which are based on different scales), and makes it possible to formalize the effective relations. This circumstance lays the track to the discovery of 'laws of nature' in the form of invariant quantity equations, which make it possible to generally explain a certain behaviour of objects and to break it down into formal 'conditional relations'. The formalization of the relations in the form of theory is a generalization of higher potency, but the basis is formed by transcendental concepts, and these are also the reason for the normative claim of the 'laws of nature' (in relation to the manifold individual objects or cases). The physical theory or the law of nature in its form provides the general, transcendental reason for a certain behaviour of things. The 'explanation' of behaviour, in contrast, corresponds to the conditional view.[79]

(d) The question of reference. From an epistemological point of view, the question of reference in relation to the 'theoretical concepts' of physics is of fundamental importance. The entire understanding of physics as a science, the decisive question of its relation to reality, depends on it.

It is in the nature of the naïve, object-related understanding of cognition that something in the (autonomous) objects (in the sense of 'properties') must correspond to our terms, something to which they refer. In this view, this is of course also true for the 'theoretical concepts' of physics (which in this respect are not easy to comprehend), and in the case of the postulation of 'unobservable entities' this becomes even more acute, to the point of doubt about their real existence, the subject of the debate on so-called 'scientific realism'.

According to the view of the transcendental cognitive concept of physics presented here, however, the 'theoretical concepts' of physics are not at all terms in the usual sense, which refer to objects or their properties (or 'mentally represent' them), but rather transcendental concepts, which presumptively substitute the objects (in the heuristic explanatory context). As far as one can speak of 'representation' in relation to the physical concepts, it concerns the physical base quantities (values).[80] The only form of direct reference to the individual (concrete) objects in the context of physical cognition is measurement.[81] Incidentally, what does not apply to direct observation, namely the fulfilment of the essential condition of substantive certainty, unambiguity, applies to measurement.[82]

Everything said so far, however, refers mainly to classical physics. For this, the reference to the existing objects (in the form of the measurement) is essential. Their ontological position in relation to the objects is ambivalent, because it undermines their autonomy, but nevertheless they are indispensable for them as reference points or clues. The transcendental approach to knowledge and

79 It is the transcendental aspect of 'reasoning' that is crucial for an adequate understanding of physics and its generalizing heuristic approach. For the aspect of the causal 'explanation' related to each individual event is a practical cut that disregards the specifics of the physical heuristic access. The causal principle, to which the explanation refers, is a purely heuristic principle, and as such, as already mentioned, is compatible with any kind of explanation or interpretation of events. From the point of view of mere 'explanation', the physical explanation is therefore in competition with all other possible types of explanation. See Paul Feyerabend's radical motto: "Anything goes" (Feyerabend, P. (1986), p. 32). The distinction between 'reason' and 'explanation' corresponds to the 'deductive-nomological' model of explanation of Hempel and Oppenheim. Their "basic idea is that an explanation must take the form of a sound deductive argument in which a law of nature occurs as an essential premise. (Woodward, J. (2003), p. 152)

80 In this context, one might rather speak of a relationship of translation, because, as in the experimental concept-finding process in general, the interlocking of procedures and aspects is characteristic here as well. This means that the measurement is part of the concept-finding process from the very beginning, and is therefore guided by heuristic aspects (selection of basic parameters).

81 In the context of the object-related understanding of cognition, this often leads to interpreting the approach of physics in terms of mere abstraction and technical mastery of nature.

82 At least until the emergence of the theory of relativity, which also includes the standpoint of the measurer in the conditional context and thus in the investigation of the conditional relations. By the way, the assumption or discovery of constants is of special importance in the context of the approach of physics in general.

the object-related perception of knowledge somehow balance each other out.[83] This is also made clear by the common interpretation or perception of physical concepts in categories of 'properties' of objects. This assimilation of the transcendental concepts into the object-related perception of cognition is of course favoured by the affinity of the concepts of classical physics, which transcend the objects, to the observable properties of the objects.[84] Finally, the process of concept-finding itself is also based on the observation of the behaviour of the objects. This changes fundamentally with the transition to microphysics. The phenomena now take over the sole leadership in concept-finding, the 'objects' come out of the game and, in a sense, only reappear in the form of 'theoretical entities' (one could also say that they come back in this form 'through the back door').

The discovery and experimental investigation of electrical and magnetic phenomena marks an ontological break in this respect: the end of object ontology (but not of object thinking!). The objects (as points of reference) are increasingly coming out of the game methodically, the phenomena as such take the lead in the conceptualization. This involved a whole spectrum of phenomena, each of which was initially puzzling both individually and in their connection to one another, and which led to a long and difficult process of theory building and concept-finding, in which the interpretation of the phenomena and their explanation go heuristically hand in hand.[85] Phenomenal and transcendental aspects intermingle, the phenomena in question no longer have an external reference point for their explanation in terms of their interpretation as indications. Only the occurrence of the phenomena themselves provides a point of reference for drawing conclusions about inherent conditional relationships from the heuristic point of view of establishing exact correlations (in connection with the active evocation of the phenomena under controlled conditions).[86] In this respect one can speak of a 'reasoning explanation'.

What follows from this for the transcendental and ontological status of the concept of 'electric charge', as a result of the process of concept-finding, which as a key to the phenomena finds its way into different branches of physics and chemistry, and on the way via the 'rediscovery' of atomic theory becomes the basic concept of microphysics?

The concept basically 'refers' to the phenomena in question as an indication, and via phenomena also to the respective 'charge carriers' (entities, particles). The indicative character is thus also transferred to the entities themselves. The concept is thus logically primary in relation to the entities, and in this respect materially unbound. It is equally a transcendental concept and a principle. The concept 'electric charge' itself, in contrast to the concepts of classical physics, does not correspond to a basic physical quantity.[87]

The 'contingent objects' have thus become obsolete as theoretical points of reference; they are replaced by 'theoretical entities'. For them, the connection with the explanation of the phenomena is constitutive 'a priori'. They are not simply found and 'described', or measured, but they are defined, supposed and detected by means of the analysis of the phenomena on the basis of the transcendental

83 The heuristic approach of physics indirectly questions the object-related perception of cognition, but without paying special attention to this fact. It is a fundamental characteristic of physics that it (initially) simply leaves the 'big questions' of ontology and epistemology open. This is an important aspect of its status and nimbus as basic research, that it does not approach things with ready-made answers to fundamental questions.
A (future) scientific epistemology will not be able to start from the assumption of the autonomy of the subject, but will have to start from the consideration of cognition as a 'phenomenon'. See the opening quotation by Erwin Schrödinger.

84 From the general, object-spanning perspective of the theory, the 'properties' of individual objects should actually be referred to as 'characteristics'.

85 The difference to the situation in classical physics is mainly based on the fact that in classical physics the phenomena as such were undisputed. I refer to the description by Thomas Kuhn (in: Kuhn, T. S. (2012), pp. 14-22 and 117-118).

86 Whereas in classical physics experiments were heuristically guided by theory building and concept finding, experiments now conversely heuristically guide theory building and concept finding.

87 The base quantity ('ampere') corresponding to this does not refer to the singular entities (the 'charge carriers'), but to 'quantities', to the intensity of the flow.

concepts (which include not only the 'electric charge' but also other concepts such as 'mass').

What is important is that the transcendental status of the concepts refers to the phenomena (the explanation of which is at stake), not to the entities! Unlike the objects to which classical physics refers, these are not substituted by the concepts, but are themselves indirectly part of the concept.[88]

The theoretical entities are, as said, 'defined' by the concepts, and thus 'subsumed' under them in a metaphysical (directly 'descriptive') view (see the 'Table of Elementary Particles'). Thus, in our 'imagination', they again approximate the objects of metaphysics in a deceptive way!

So it is not surprising that at this point usually - completely inconspicuously - the naïve, object-related concept of cognition again takes over the command over our thinking (and thus the eignty of interpretation over theory), and with it the corresponding concept of reality, namely the idea of the independent (autonomous) determinacy of objects (in this case the 'charge carrier'). This is reflected in the ontological interpretation of the 'charge' as a 'property' of the charge carriers, and thus in the assertion of the ontological primacy of the substance (charge carrier) over the properties, - that means, in transfer to the elementary particles: their conception as 'building blocks of matter'.

The best-known ontologically formulated position opposing this view is the so-called 'ontic structural realism', an approach that attempts to derive far-reaching ontological conclusions from physical research results, but without critically addressing the question of the cognitive concept of physics.[89]

3. Physics and ontology

The ontological concept of autonomous substance is the foundation of our conception of reality. Not only the concept of 'properties' depends on it, but also other concepts such as 'causality' or 'force' etc. John Locke writes impressively about its transcendental status: „The *Idea* then we have, to which we give the general name Substance, being nothing, but the supposed, but unknown support of those Qualities, we find existing, which we imagine cannot subsist, *sine re substante*, without something to support them, we call that Support *Substantia;* which, according to the true import of the Word, is in plain *English, standing under, or upholding*. An obscure and relative *Idea* of Substance in general being thus made, we come to have the *Ideas of particular sorts of Substances*, by collecting such Combinations of simple *Ideas,* as are by Experience and Observation of Men's Senses taken notice of to exist together, and are therefore supposed to flow from the particular internal Constitution, or unknown Essence of that Substance. Thus we come to have the *Ideas* of a Man, Horse, Gold, Water, *etc.* of which Substances, whether any one has any other clear *Idea*, farther than of certain simple *Ideas* coexisting together, I appeal to every one's own Experience.“[90]

At the core of the concept of substance is the idea of autonomy, of the autonomous existence and determinacy of things as real, distinct units. What makes this transcendental concept so essential (and seemingly indispensable) for our thinking is the fact that it forms not only the horizon of understanding for things (and ourselves), but also the basis and prerequisite for our naïve (essentially passive, receptive) understanding of cognition.

Nevertheless, manifest problems arise from this, especially in the field of quantum physics. Accordingly, it is also this core of the concept of substance, autonomy, which is decidedly contradicted by the so-called 'ontic structural realism' ('OSR'), using empirical arguments.

88 From the overall view of reality (consisting of phenomena and entities) they are therefore theoretical concepts and theoretical entities.

89 The starting point of structural realism, however, is an epistemological problem, namely the question or the search for an element of continuity in the change of physical theories. (See also: Ladyman, J. & D. Ross (2007), p. 67). This problem is a direct consequence of Popper's focus on mere theory, i.e. his erroneous renunciation of a rational understanding of the process of theory-building and concept-finding.

90 Locke, J. (1979), p. 296

In the following brief outline of his position and argumentation, I refer to the presentation in the work "Every Thing Must Go" by James Ladyman and Don Ross (together with David Spurrett and John Collier), which offers an impressive overview of the scientific and philosophical positions and debates in this context. I would like to start with a few key statements.

„Ontic Stuctural Realism (OSR) is the view that the world has an objective modal structure that is ontologically fundamental, in the sense of not supervening on the intrinsic properties of a set of individuals. According to OSR, even the identity and indivuality of objects depends on the relational structure of the world.“[91] „Ernst Cassirer rejected the Aristotelian idea of individual substances on the basis of physics, and argued that the metaphysical view of the 'material point' as an individual object cannot be sustained in the context of field theory. He offers a structuralist conception of the field. [Quotation:] The field is not a 'thing', it is a system of effects (*Wirkungen*), and from this system no individual element can be isolated and retained as permanent, as being 'identical with itself' through the course of time.“[92] This thesis is supported by the statement: „When it comes to fundamental physics, objects are very often identified via group theoretic structure.“[93] And then continue: „To be an alternative to both traditional realism and constructive empiricism, structural realism must incorporate ontological commitment to more than the empirical content of a scientific theory, namely to the 'structure' of the theory. We have argued that relational structure is ontologically subsistent, and that individual objects are not. However, the idea that there could be relations which do not supervene on the properties of their relata runs counter to a deeply entrenched way of thinking.“[94] After a detailed discussion of the arguments for different positions on this fundamental ontological question Ladyman and Ross come to the conclusion: „There is thus growing convergence among philosophers of physics that physics motivates abandonment of a metaphysics that posits fundamental self-subsistent individuals. Since this is essentially a negative point, it might seem to be grist to the mill of the constructive empiricist.“[95] They justify their own position by citing arguments against the epistemological standpoint of 'constructive empiricism' and thus come to the conclusion: „We thus suggest that in addition to the negative thesis that physical theory should not be interpreted in terms of underlying objects and properties of which the world is made, we are motivated ... to take seriously the positive thesis that the world is structure and relations. Individual things are locally focused abstractions from modal structure. By modal structure we mean the relationships among phenomena.“[96] They counter the argument "relations are impossible without relata" with the remark: „A core aspect of the claim that relations are logically prior to relata is that the relata of a given relation always turn out to be relational structures themselves on further analysis. … We may not be able to think about structure without hypostatizing individuals as the bearers of structure, but it does not follow that the latter are ontologically fundamental.“[97]

The ontological position of ontic structural realism thus consists essentially in the assumption of the 'primacy of structures and relations over relata' (over 'substances'). However, the argument for 'the claim that relations are logically prior to relata' is merely an empirical one ('that the relata of a given relation always turn out to be relational structures themselves on further analysis'). This is the core of the OSR's problem, the conclusion on the 'logical' primacy of relations is based on an argument 'a posteriori'. The reason for this problem lies, as I will try to show, in the naïve, passive

91 Ladyman, J. & D. Ross (2007), p. 130.

92 Ladyman, J. & D. Ross (2007), p. 140. The original quotation reads: „Das Feld ist kein 'Ding', es ist ein System von Wirkungen; und aus diesem System läßt sich nicht ein einzelnes Element herauslösen und als permanent, als im Laufe der Zeiten 'mit sich selbst identisch' festhalten.“ (Cassirer, E. (2004), p. 213)

93 Ladyman, J. & D. Ross (2007), p. 145

94 Ladyman, J. & D. Ross (2007), p. 148

95 Ladyman, J. & D. Ross (2007), p. 153

96 Ladyman, J. & D. Ross (2007), p. 153

97 Ladyman, J. & D. Ross (2007), p. 155

understanding of cognition (in the dress of 'objective cognition', supplemented by 'institutional norms'),[98] which assumes the 'objective determination' of objects. According to Ladyman and Ross, however, it now turns out 'objectively' that (at least "according to the OSR), even the identity and individuality of objects depends on the relational structure of the world. Hence, a first approximation to our metaphysics is: 'There are no things. Structure is all there is'."[99]

A similar conclusion emerges, albeit purely logically (quite independent of empiricism), if the concepts of physics (in accordance with her transcendental heuristic approach) are not understood in a descriptive (predicative) sense (i.e. assuming that they 'refer to the objects'), but in a transcendental sense, as transcendental concepts (which she uses) to presumptively investigate the phenomena, and whose reference to the objects is therefore only an indirect one). A condition for the ontological relevance of these concepts is the regard for their subject-independence. For as essential as the reflection of cognition is (especially for an adequate understanding of physics), so unfounded is the scientific status of epistemology.

So let us go back to the concept of 'electric charge', and its transcendental position in relation to the 'reasoning explanation' of the phenomena. I would like to begin again with a quotation from Ernst Cassirer: "Since the study of the facts of electrolysis, since the research on the nature of cathode rays and on the phenomena of radioactivity, the foundation has been laid for a theory of matter which attributes to it a purely electrical constitution. The concept of electric charge is now being introduced as the very basic element of the knowledge of nature, and development is increasingly pressing for the mass of the electron to be regarded only as an 'apparent mass' and to be completely dissolved into the electric charge ."[100]

The concept of 'electric charge' is, as we have established, logically primary in relation to the 'charge carriers', since it cannot be 'deduced' from the carriers themselves, but only from the reasoning explanation of the phenomena. Nevertheless, we usually qualify the 'electric charge' (following the logic of our understanding of cognition, respectively the 'objective cognitive attitude') as 'predicate', as a 'property' of the charge carriers.

If we start from the assumption it quickly becomes clear on closer reflection that this concept, due to its binary logical structure, makes a mockery of its substance-ontological view as a 'property' or 'predicate'.[101] For the basis of this concept, the difference between 'positive' and 'negative' charge, is the manifestation of a purely logical distinction, not a contingent one (with reference to a certain spectrum, such as 'white' or 'black'). This means that their 'parts' are defined exclusively with reference to each other, they cannot be defined separately, independently of each other (with reference to a generic term or a spectrum of terms). What logically characterizes this distinction, therefore, is not the difference as such (as merely semantic), but rather the inherent unity in the difference, its binary logical character. The semantic distinction as a 'logical unit' is completely

98 „Thus science is, according to us, demarcated from non-science solely by institutional norms: requirements for rigorous peer review …, requirements governing representational rigour ...“ (Ladyman, J. & D. Ross (2007), p. 28)

99 Ladyman, J. & D. Ross (2007), p. 130

100 The original quotation reads: „Seit der Erforschung der Tatsachen der Elektrolyse, seit den Untersuchungen über die Natur der Kathodenstrahlen und über die Erscheinungen der Radioaktivität ist der Grund zu einer Theorie der Materie gelegt, die ihr eine rein elektrische Konstitution zuschreibt. Der Begriff der elektrischen Ladung wird jetzt als das eigentliche Grundelement der Naturerkenntnis eingeführt, und die Entwicklung drängt immer mehr dazu, auch die Masse des Elektrons nur noch als 'scheinbare Masse' anzusehen und sie ganz in die elektrische Ladung aufzulösen.“ (Cassirer, E. (2004), p. 179). Cassirer himself, however, as a 'Neo-Cantian', immediately switches back to the 'epistemological' point of view, when he sees, immediately after this quotation, precisely in the heuristic value of the atomic models their 'epistemological barrier'. Epistemology beats heuristics.

101 This further reflection is usually blocked by the fact that we are used to avoiding all 'speculation' when faced with 'metaphysical difficulties'. After all, it is precisely such 'speculation' that has discredited metaphysics, and epistemology has basically pulled the teeth of this 'speculation' by imposing an intellectual ban on holism through the criterion of 'certainty' (and the associated reinterpretation of the holistic cognitive situation into a linear relationship). In this sense, the 'empirically based' holism of the OSR is revolutionary, but it does not go to the roots.

'autonomous', it does not point in any way 'beyond itself', while the 'parts' are completely dependent.

In the language of classical metaphysics: the specific generality of the contrary determinations (positive or negative, +/-) associated with the concept of 'electric charge' is suspended binary logically (not dialectically) in the pure generality of its inherent unity in difference, for neither side can be thought logically without the other.[102] This high degree of generality corresponds to a 'minimal holism', whose respective 'determinations' (thought in a predicative sense) refer to nothing else but their interrelation. The (minimal) holistic frame of reference is logically primary in relation to the semantic reference.[103]

With regard to elementary particles, four (onto)logical conclusions result from this:

a) For logical reasons, the 'electric charge' cannot be understood as an intrinsic 'property', as a simple 'quality' (but rather as a 'feature' in a structural context). The concept of 'electric charge', in the light of its binary structure, completely excludes the possibility that the entities in question (the 'charge carriers') can be regarded as independent (let alone autonomous) substances (and consequently not the elementary particles as 'building blocks').[104]

b) The abandonment of the idea of the autonomy of the (elementary) entities logically (purely formally) necessarily leads to the idea of the primacy of the constellation.[105] In contrast to the 'structure', the 'constellation' is never something 'objectively' given or ascertainable, because formally seen it has nothing 'outside itself', it always includes (on closer consideration) the 'observer' (and his point of view). The reference to individual, concrete constellations necessarily involves the taking of a standpoint.[106]

c) Autonomy is therefore exclusively on the side of the overall constellation. This means that processuality is the foundation of reality.[107] 'Partial autonomy', as far as it can be spoken of, therefore never exceeds the status of contingent (more or less strong) autonomy. The formation of spatio-temporally stable units can accordingly only be thought of according to the principle of 'contingent autonomy' (more on this later).[108] Their 'properties' therefore basically have an emergent

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102 The analogy to the unit of the 'bit' (0/1) is obvious. '0' in this case means nothing else but the absence of '1', vice versa. The synthetic unit in the difference also corresponds to what Hegel understands by 'reiner Begriff' ('pure term').

103 The conceptual distinction between positive and negative charge has therefore a more or less cipher character for a basic polarity.

104 If the metaphysical longing of physics (whose reason, as mentioned above, lies in the concept of cognition) expressed in it is not fulfilled in this way, it is fulfilled in another way. For the unity it encounters is not an ultimate unity in the intended sense of indivisibility (and thus in the sense of a substance-autonomous singularity determined in itself), but rather unity in the sense of principle inseparability. Werner Heisenberg writes in this context: "'In the beginning was symmetry', that is certainly more correct than the Democritical thesis 'In the beginning was the particle'. The elementary particles embody the symmetries, they are their simplest representations, but they are only a consequence of the symmetries." (Heisenberg, W. (2017), p. 280. [The original quotation reads: „'Am Anfang war die Symmetrie', das ist sicher richtiger als die Demokritsche These 'Am Anfang war das Teilchen'. Die Elementarteilchen verkörpern die Symmetrien, sie sind ihre einfachsten Darstellungen, aber sie sind erst eine Folge der Symmetrien.“]). However, this again shows the 'objective attitude to cognition'.

105 I'm quoting Ladyman and Ross: „As Ernan McMullin says: 'imaginability must not be made the test for ontology' ...“ (Ladyman, J. & D. Ross (2007), p. 132)

106 The notion of 'objective cognition' is based on the assumption that there is a standpoint 'outside' the overall constellation (an 'uninvolved observer'), according to the linear subject-object scheme of epistemology. The primacy of the constellation means, in sum, that every conceivable fixed reference point of cognition is eliminated. The overall constellation can only be understood in a transcendental perspective, and in order to characterize it as a 'concretum', it is necessary to start from it as an 'abstractum'.

107 I refer again to a quote from Ladyman and Ross: „Consider [Lee] Smolin: 'The universe is made of processes, not things' … Smolin insists that a lesson of both relativity theory and quantum theory is that processes are prior to states.“ (Ladyman, J. & D. Ross (2007), p. 172)

108 This kind of understanding of unity is basically also addressed by Carl Friedrich von Weizsäcker when he writes: "The smallest body that can exist on its own, consisting of matter, is the atom. (Weizsäcker, C. F. v. (2004), p. 148.

character.

d) Space and time are not somewhat independent, separate from the constellation, they are rather an integral 'part' of it. But since the constellation is not itself 'something', separate or independent from its 'parts', but nevertheless the determining factor, space and time are both aspects and (effective) factors of the constellation.

This already indicates that the previous presentation, which referred to purely formal, logical aspects, does not of course provide a complete picture. For it ignores the fact that the structural ('binary logical') unity in the difference at the level of microphysics, unlike the 'bit' (as the basic unit of information), is not a purely logical, conceptual one, but an intrinsic, virulent, and therefore necessarily dynamic one.[109]

The incompleteness of the picture of the structural unity in difference at the level of microphysics refers, apart from this, but also and above all to two factors which, in their combination, lead to the dynamics that simultaneously create and destroy order. One (internal) factor is the fact that there are, of course, other structure-forming elements or constituents in addition to the electric charge, such as spin, without which the aforesaid virulence would presumably end in self-extinction.[110] The other (external) factor consists in the simple fact of imbalances, which is due to the fact that the principle of structural unity in difference is constraining in its effect and at the same time unconstrained in its effectiveness.[111] Constraining, because it has a 'local' demarcating effect (through the establishment, i.e. formation and virulent maintenance, of relatively autarkic structural units in the form of dynamic equilibria), and unconstrained, because precisely this principle as such is overarching, and therefore every change in one place has a direct effect elsewhere, and on the overall constellation.

This also means, however, that the structural unity in the difference 'in concreto' is not a 'static' unity, but a dynamic, synthetic (structure-forming) unity, one that is constantly established and maintained (in a virulent manner), and this 'simultaneously' on the most varied (through the action and interaction itself 'produced') levels of virulent action and interaction, which influence each other instantaneously, just as the overall constellation, which alone is autonomous, and which therefore as such also has an effect on all other levels.[112] Finally, it is the fact that autonomy lies exclusively on the side of the overall constellation (on the global level of action and interaction, which includes all other levels) that is the reason for being able to speak of a universal determinism, but - and here lies

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[The original quotation reads: „Der kleinste für sich existenzfähige aus Materie bestehende Körper ist das *Atom*.“]). A special form of self-sufficient unit, which I can only suggest here, are the 'living units', which (in their dependence on the supply of energy) are to be understood according to the principle of 'precarious autarky'.

109 I think that Carl Friedrich von Weizsäcker's concept of 'primal alternatives' ('Ur-Alternativen') disregards precisely this difference between the merely logical and the virulent (and therefore also overarching) form of the principle. This difference between the logical (tamed) and the virulent form of the principle corresponds on another level to the difference between the binary structure of the machine code and its electronic processing.

110 But the discreteness of the values of the electron spin also suggests an immanent systemic connection. The 'grammar' of the formation and development of the constellations is thus also influenced by other factors, but this does not play a significant role for the basic ontological argumentation. In view of the phenomenon of quantum coherence, however, it is conceivable that the structural unity in difference itself is an emergent phenomenon, which is based on an even more fundamental form of differential unity.

111 It is this form of 'unity of fact and principle' that leads to emergence. One can of course associate the existence of imbalances in an even more primal sense with the quantum physical concept of 'decoherence'.

112 One might think here of Leibniz's idea of 'pre-stabilized harmony', but also of a blind, 'self-controlling' algorithm, driven by the principle of synthetic unity in difference (in combination with its 'binary-logical' foundations and the factor 'decoherence'), whose blindness is due to the fact that it has nothing 'outside itself', that its 'logic' is purely immanent (determined by the overall constellation). The fundamental understanding of pure immanence is also the necessary condition for an adequate heuristic approach to the issue of the genesis of 'consciousness' (in connection with the issue of the constitution of units within the framework of the overall constellation, proceeding from the specificity of the 'living units', their 'precarious autarky', their dependence on the availability of energy through which, within the framework of the constellation, 'reception' and 'distinction' at the elementary level comes into play).

the difference to the 'metaphysical' idea of determinism based on the notion of causality - a non-linear determinism, one without fixed reference points.[113] The notion and question of (linear) causality always involves a point of view and concrete reference points, and is therefore related to the question of the constitution of units and the emergence of properties.

What is essential is that, due to the primacy of the constellation, no real, 'local' units are conceivable that are not themselves constellations within the framework of constellations, and ultimately of the overall constellation.[114] The dictum 'the whole is more than the sum of its parts' is insofar only half the truth, because the whole is at the same time the generic principle of the parts. The constellation does not 'consist' of independent 'parts', but the constitution of units (with a certain 'independence') is itself part of the formation of the overall constellation as an infinite process.[115] The model 'autonomy' is therefore ruled out from the outset with regard to the question of the ontological status of 'local units', because for logical reasons autonomy lies exclusively on the side of the overall constellation.[116] The only model that logically comes into question under these circumstances is the model of autarky, which at the same time provides an answer to the question of the constitution of 'local units' according to the 'electrical potential' of the elementary entities.[117] Autarky as a model corresponds to the principle of synthetic unity in difference as the 'principium individuationis' of physics, which is not only the principle of the constitution of 'local units', but also the principle of their decomposition, the fundamental transience of these units (entropy). For this reason, autarky is also fundamentally a matter of contingency.

Directly related to this is the topic of 'properties' or 'qualities'. A distinction must be made between the 'properties' of the units concerned, which concern the spatio-temporal constellation - namely the extension, the behaviour in time relative to position, and the mass, which are the subject of classical physics - and the emergent 'qualities' (or also 'forces'), which are connected to their constitution, or to their autarky within the framework of the constellation, and the interaction based on it, or connected with it.

In reality, both 'types' of qualities are of course inseparable, for both the extension, mass and behaviour in time are directly related to the factor constitution (and subsequently cumulation). In

113 In this sense I again agree with Ladyman and Ross when they write: "The tentative metaphysical hypothesis of this book, which is open to empirical falsification [?], is that there is no fundamental level, that the real patterns criterion of reality is the last word in ontology, and there is nothing more to the existence of a structure that what it takes for it to be a real pattern. (Ladyman, J. & D. Ross (2007), p. 178). However, I do not think (as the question mark indicates) that this question is an empirical one. The point is simply that the constellation is the basic logical reality that accounts for all differentiations and has nothing outside itself.

114 The differentiation of constellations within the framework of the overall constellation (we will talk about this in the sense of 'milieu formation' in a moment) is related to the already mentioned 'local effect' and 'global effectiveness' of the principle of synthetic unity in difference.

115 This is the difficulty of describing the overall constellation, that in order to describe it as a 'concretum' (i.e., with reference to the influence of the constitution of units), one must always start from it as that 'abstractum' as which it also 'works in the background', while the constitution of units exerts its own influence (in an emergent manner). In this sense, I think that also Michael Strevens' critique of 'compositional theories' by way of the 'aggregation problem' is to be understood. He writes: "I call the relations between spatiotemporal parts sensitive because their effect on the aggregate is sensitive to small changes in the state of the part. ... The relations between spatiotemporal parts are combinatorially complex because, as you increase the number of objects, the number of relations to keep track of increases. (Strevens, M. (2017), p. 45)

116 I'm quoting Ladyman and Ross again: „Both QM [quantum mechanics] and relativity theory teach us that the nature of space, time, and matter raises profound challenges for a metaphysics that describes the world as composed of sellf-subsistent individuals.“ (Ladyman, J. & D. Ross (2007), p. 151)

117 In the section "Rainforest Realism and the Unity of Science", Ross and Ladyman (together with John Collier) suggest 'cohesion' as a 'useful idea' regarding the constitution of 'objects' within the OSR: „Collier … offers an alternative metaphorical framework for the relevant notional space in saying that an object coheres when the balance of intensities of 'centrifugal' and 'centripetal' forces and flows acting on it favours the 'inward' ('centripetal').“ (Ladyman, J. & D. Ross (2007), p. 246f.). In the metaphorical character of this idea (which the authors also note self-critically), the problem of the inadequacy of the 'objective cognitive attitude' is again apparent when it comes to transcendental questions.

this respect (according to the thesis of the primacy of the constellation) all properties and qualities of concrete units are fundamentally emergent in nature.[118]

Robert B. Laughlin writes: "The laws of motion of electrons give rise to the laws of thermodynamics and chemistry, which give rise to the laws of crystallization, which in turn give rise to the laws that control hardness and malleability, from which the laws of technology are derived. Thus the world of nature represents an interdependent hierarchy of descent ..."[119] And elsewhere: "All fundamental constants require the context of an environment to make sense. In practice, there is no distinction in physics between reductionist and emergent quantities." [120]

The dynamic constitution of 'real', contingent autarkic, 'local' units, as well as the 'local' interaction based on this constitution of units is the reason and principle of the emergence of 'properties' (or 'qualities' or 'forces'). The emergence of 'properties' correlates with the virulence of the relationships at the elementary level. It has the character of an evocation by the energetic interaction based on the constitution of 'local' units within the framework of the general interdependence owing to the autonomy of the overall constellation.[121] The 'properties' are not the 'result' of the interaction, not something different from it, but they are evoked and processed in equal measure by the interaction, through which the 'real' ('figurative') units first become 'concrete' units. Their status is a purely processual one, it is a matter of a 'determinacy in flux', for 'constitution' and 'interaction' are purely 'immanent' processes, they are directly real and effective, and therefore completely 'blind'.[122] The 'binary logic' principle of the 'synthetic unity in difference' in its 'real' instantiation - with its onto-logical consequence of the primacy orthe autonomy of the overall constellation, in connection with the corresponding principle of the 'contingent autarky' of real, 'local' units - is inherently generic, resembling a direct blind, viral, generic algorithm.[123]

One such 'processual property' evoked by the interaction of elementary 'local' units on the basis of their constitution (autarky) within the overall constellation is cohesion, with the consequence of accumulation, the formation of more comprehensive units. As Ladyman, Ross and Collier write: "The key conceptual job performed by cohesion is that it is an equivalence relation that partitions sets of dynamical particulars into unified and distinct entities."[124]

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118 The words with which Ladyman and Ross quote Johanna Stachel, namely „that in so far as the entities of modern physics have individuality they 'inherit it from the structure of relations in which they are enmeshed' ...“ (Ladyman, J. & D. Ross (2007), p. 153), apply to all kinds of entities.

119 Laughlin, R. B. (2007), p. 26. This quotation has been retranslated from German, where it says: „Die Gesetze der Bewegung von Elektronen zeugen die Gesetze der Thermodynamik und der Chemie, welche die Gesetze der Kristallisation zeugen, die wiederum die Gesetze hervorbringen, von denen Härte und Formbarkeit gesteuert werden, woraus die Gesetze der Technik hervorgehen. Demnach stellt die Welt der Natur eine interdependente Hierarchie der Abstammung dar ...“

120 Laughlin, R. B. (2007), p. 41. This quotation has been retranslated from German, where it says: „*Alle* fundamentalen Konstanten setzen den Kontext einer Umgebung voraus, um einen Sinn zu ergeben. In der Praxis gibt es in der Physik keine Unterscheidung zwischen reduktionistischen und emergenten Größen.“

121 The autonomy of the overall constellation basically corresponds to the the theorem of conservation of energy. I am quoting Ladyman and Ross again here: „Consider David Mermin's 'Ithaca' interpretation of QM, according to which: 'Correlations have physical reality: that which they correlate does not'. … Mermin argues that the physical reality of a system consists in: (a) the (internal) correlations among its subsystems; (b) its (extenal) correlations with other systems, viewed together with itself as subsystems of a larger system.“ (Ladyman, J. & D. Ross (2007), p. 187)

122 This aspect is of fundamental importance with regard to the topic of the genesis of 'consciousness' and ultimately also for the concept of 'cognition'. For the question of the reason (and the conditions of possibility) of the occurrence of 'definite determination' (building on this purely processual determination) is the key to understanding the phenomenon of 'consciousness'.

123 In a way, this could be considered the 'operating system' of the universe. See for example Anton Zeilinger, who writes: „Information ist der fundamentale Baustein des Universums.“ ("Information is the fundamental building block of the universe.") (Zeilinger, A. (2005), p. 73). I would like to quote Ladyman and Ross here again, who write: „[David] Mermin … suggests that … we should abandon the search for a substratum for quantum information in physics. However, he thinks there is a reality of qualia not described by physics.“ (Ladyman, J. & D. Ross (2007), S. 188).

124 Ladyman, J. & D. Ross (2007), p. 248. And further down: „The job the concept performs is a scientific one: it gives

In order to elicit the ontological consequences of the thesis of the 'primacy of the constellation', it is necessary to illuminate the constitution of real, contingent autarkic, 'local' units from the standpoint of the (autonomy of the) overall constellation. The following aspects must be taken into account:

a) The constitution of real, contingent autarkic (atomic) units has, from the perspective of the overall constellation, the status and character of the formation of specific constellations within the framework of the overall constellation, which thus 'transforms' itself or splits itself into a myriad of 'local' constellations that necessarily (blindly) interact with each other, because autonomy lies solely on the side of the overall constellation. The constitution of real, contingent autarkic units can be understood 'objectively' as a process of 'structure formation', but from an 'immanent' perspective, i.e. from the perspective of the overall constellation (taking into account its autonomy), it has more the character of a permanent dynamic '(re-)configuration'.

b) Through the constitution (and subsequently the formation) of 'local' autonomous units and the associated emergence of 'qualities' (and, mind you, also 'qualities' and 'forces') on the basis of the constitution and interaction of these units, the 'initiative' of the development of the overall constellation passes from the 'global' to the 'local level' to a high degree. The dynamics of its development is thus decisively determined by the 'local' factors (the units, their interactions, and the 'qualities' and 'forces' appearing therein). The autonomy of the overall constellation remains fundamentally unaffected by this.

c) The constellation has it in itself that every change within the framework of a constellation (or part of a constellation) also directly means a change of the constellation as such (the entire constellation), and in this respect one can speak of a mutual penetration of the 'local' units ('atomic constellations') and the constellation(s) of their 'surroundings', as well as the overall constellation.[125] All constellations influence each other reciprocally, and can therefore only be demarcated from each other to a limited extent.[126] Due to this continual reciprocity, what appears as a 'structure(formation)' in the 'objective cognitive attitude' (the 'presence' or formation of 'units') in the context of a larger constellation always has the character and effect of a 'milieu formation' at the same time (on all

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individuation conditions for dynamical entities, constructed out of measurement data by observers for second-best keeping of epistemic books.“ This concept is, as I said, based on the 'objective (descriptive) cognitive attitude'. The fact that it is not a fundamental concept can be seen from the circumstance that cohesion (as well as its extreme opposite, the explosion) is of emergent origin, i.e. evoked by interaction. It 'is' (from an immanent point of view) a form of interaction.

125 It is this aspect of the constellation, by the way, that makes up the attraction of many games, whereby the rules of the game take over the part of the autonomous principle, which determines the formation and change of the constellations, and their emergent impact, from the background (the options change 'step by step', with every move, which is reflected in their evaluation from case to case). The so-called 'Rubik's cube' is also based on this principle and provides a good picture. Is the cube with which 'God plays' (in allusion to Einstein's 1926 statement that 'God does not play dice') a kind of gigantic Rubik's cube? Then Einstein would be right and wrong at the same time. For the truth lies not on the level of stochastics, which is simply an indication of the elementary unpredictability, not of indetermination (which was critically alluded to by Einstein). The truth lies rather on the level of the autonomy of the overall constellation and the principle underlying its formation (or formative evolution), which implies the perfect determination of the level to which stochastics refers, but which is and cannot be visible on this level (of the 'concrete'). The principle of synthesis (alias 'the rule of the game') eludes analysis at the level of the (seemingly autonomous) concrete. The constellations are non-linearly determined. Linearity is (as far as it can be mentioned at all) a special case of non-linearity. One can also speak of a permanent violation of the 'principle of locality'.

126 The change of a 'local' constellation is (in a purely logical sense) instantaneously a change of the overall constellation, but this does not apply to the influence, because this is 'moderated' by the interaction (the emergence of 'properties') and the factor space-time. In this sense, the phenomenon of 'entanglement' can theoretically be regarded as a 'logical case' of the principle of 'milieu formation', in the sense of instantaneous mutual influence (in the form of strict correlations) by a constellation (which would indicate an even more original instantiation of 'synthetic unity in difference' as the 'foundation' of reality than the 'electric charge').
To gain an 'objective picture' of individual constellations or of the overall constellation is in any case impossible from this perspective. Ladyman and Ross refer in this sense to Lee Smolin with the "suggestion that it is impossible to describe the whole universe at once, not because of epistemological difficulties but because there is no fact of the matter about its state.“ (Ladyman, J. & D. Ross (2007), p. 188, note 99)

'levels'), which 'milieus' can of course also be very stable in turn.[127]

d) I have already mentioned that space and time are not only aspects but also factors of the constellation. But it is basically only with the constitution of 'local' units and the interaction and milieu formation that space and (with it also) time play an 'independent' role as factors of the constellation and its immanent evolution.[128] For with the constitution of units, space comes into play in terms of interaction concretely as 'distance' (and with it time as 'duration'). In this form it also becomes an influential factor in the development of the overall constellation, which can even lead to something like degrees of 'relative autonomy' of constellations.[129]

The conclusions drawn so far from the thesis of the 'primacy of the constellation' tend to point to an impenetrable complexity of the processes. However, in the form of the emergent effect of cohesion already mentioned, which leads to the formation of larger units and thus to cumulation, a (at least on the surface) opposite tendency also appears. Cumulation not only produces new 'properties' (in the way the cumulated units interact), it also counteracts the aforementioned complexity in a certain way by introducing a stronger linearity. Decisive for this is the 'mass', as a (likewise emergent) property of the concrete 'local' units, whose effective significance in relation to the 'electrical potential' in terms of the (spatio-temporal) behaviour of these units (within the constellation) becomes increasingly weighty with the cumulation.[130]

Cumulation as an aspect and factor of milieu formation, however, also produces effects of a different ('qualitative') kind through interaction. Think, for example, of factors such as air pressure or air resistance, and their influence on the behaviour (and also the persistence) of the cumulated units within the constellation. The art of the experimenter consists not least in eliminating the factor 'milieu' as far as possible by the appropriate setting.

A fundamental aspect and factor of the constellation, which is connected to the space and the constitution of units, and which, through cumulation, has a milieu-forming effect, is distribution. This applies both to the cumulated units and to the overall constellation. It does not only have an effect on the spatio-temporal behaviour of the units, but also on their aggregate states, which in turn 'effect' the behaviour, i.e. lead to the emergence of 'properties', and to mutual influences (keyword: temperature).[131]

Two extreme manifestations of the milieu-forming effect of the factor distribution, which I would like to mention here, are 'relative autonomy' and nuclear fusion. By 'relative autonomy' I mean here

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127 The 'milieu formation' is the concrete manifestation of the 'local effect and global effectiveness' of the principle of the synthetic unity in difference.

128 In a 'standing wave', for example, space and time still exist in a certain way unseparated. In it, space is pure continuum and time is pure instantaneity. With the constitution of units this relationship is reversed to a certain extent. Space partially becomes 'place' (discretum) and time becomes duration (continuum).

129 The milieu formation reflects in a certain way the dialectic between both appearances of space 'discretion' (locality) and 'continuity' (distance). From the perspective of the constellation(s), the 'curvature' of space (in its manifestation as a continuum) can be understood as an aspect of 'milieu formation' in connection with cohesion and accumulation. The 'concept of space', on the other hand, is always sustained by the production of coordinates (on the basis of one-sided reference), and this is related to the constitution of 'precariously autarkic' units and the associated transformation of the 'constellation' into a 'situation'.

130 So writes James Woodward about „macroscopic objects – their behavior is surprisingly independent of the details of the underlying physics, often depending only on very generic features of that physics.“ (Woodward, J. (2017), p. 207). Insofar as the 'properties' evoked by the interaction within the framework of the constellation structure the interaction itself, and thus also the development of the constellation(s), to a great extent, the development has fractal features. C. Kenneth Water's 'No General Structure' thesis „that the world lacks a 'the structure' that spans scales“. (Waters, C. K. (2017), p. 100) also fits into this picture.

131 Robert B. Laughlin writes with reference to 'phases of matter' in the sense of aggregate states: "Phases are an original and well-researched case of emergence, which also conclusively demonstrates that in nature there are walls defined by orders of magnitude. (Laughlin, R. B. (2007), p. 65). This quotation has been retranslated from German, where it says: „Phasen sind ein ursprünglicher und gut erforschter Fall von Emergenz, der zudem schlüssig vor Augen führt, dass in der Natur Mauern existieren, die durch Größenordnungen definiert sind.“

that the combination of large-scale factors (such as magnitude, mass, spatial distance in the sense of a certain 'isolation') with specific constellations on the microphysical level can create 'regional' (in the sense of 'planetary') conditions that (metaphorically) suggest a conception of these constellations in the sense of 'physical biotopes'. In the way of 'isolation' space thus also appears indirectly as an effective factor.[132]

Cumulation as a form of distribution (which in turn is strongly determined by the emergent factor 'mass' in connection with cumulation), has a specific emergent effect from a certain dimension (through its own 'weight' or its influence on the interaction of the cumulated units). Cumulation itself (now inwardly) has a specific milieu-forming effect (namely as a pressure chamber), which, above a certain threshold, leads to specific interactions and corresponding emergent effects, namely to the synthesis of synthetic units (through the 'violation' of their contingent autarky and the constitution of new ones, based on nuclear fusion), in which energy (in the form of light)[133] is released, which in turn exerts a massive influence on other constellations on various scales, and also plays a significant role in the evolution of life.

4. Epilogue

The primacy (and with it the autonomy) of the constellation (as a logical consequence of the insight that the 'electric charge' cannot be regarded as a 'property') automatically points to the limits of an objectifying ('descriptive') approach. There is no fixed point of reference in this purely immanent reference system of constantly changing and influencing constellations, because only the global level is autonomous, but this level itself is nothing else but the totality in all its details. There are no entities or building blocks determined in themselves, there is no linear structure, there are only constellations and processes, completely (but not linearly) determined. Linearity is (insofar as it can be spoken of at all) only a special case of non-linearity.[134] The concepts of substance and causality, identity and autonomy - as useful and understandable as they may be in the context of knowledge - stand in the way of this insight.[135] Our common understanding of cognition as such is based on these concepts, and an epistemology that builds upon them is in this respect 'ontology laden'. Since its beginnings, epistemology (and, in its entourage, philosophy of science) has understoood itself as a stronghold against metaphysics. To this end, it declares a ban on holism and elevates 'certainty' to the criterion of real knowledge, thereby transforming the holistic cognitive situation into a linear cognitive relationship. In this way, she falls victim to the belief in her own abstractions and thus also hinders an adequate understanding of the cognitive concept of physics, which in its turn leads to insights that completely undermine the basic assumptions of epistemology.
Cognition must be rethought, and the key to this task lies in the core question of classical

132 A spatial isolation whose effect (depending on the relevant circumstances or conditions with regard to the achievement of a certain emergent effect) can in principle also be simulated ('technically') in an experimental way (or e.g. also by experiments in space).

133 Light exists as a wave (as electromagnetic radiation), but also as a particle ('photon'), i.e. spatially in two different forms, as a continuum and also as a discretum. As a particle, the photon has no charge; as a particle, it is also its anti-particle. If one associates the electric charge with 'decoherence', then one can speculatively associate the process of light generation with an escape from decoherence.

134 The term 'chaos theory' for the exploration of non-linearity is basically based on the false expectation of causal linearity as the normal case. The term 'attractor' used there stands in my eyes for the factor 'milieu formation' in connection with constellations.

135 In this sense ('being' as an imperceptible, autonomous level behind the level of the perceptible), it is probably also to be understood when Martin Heidegger writes in 'Holzwege': „Das Nichts ist niemals nichts, es ist ebensowenig ein Etwas im Sinne eines Gegenstandes; es ist das Sein selbst, dessen Wahrheit der Mensch dann übereignet wird, wenn er sich als Subjekt überwunden hat und d.h., wenn er das Seiende nicht mehr als Objekt vorstellt.“ (Heidegger, M. (1963), p. 104. [Translation:] "The nothing is never nothing, it is just as well not a something in the sense of an object; it is the being itself, whose truth is then transferred to man when he has overcome himself as subject and, that is, when he no longer imagines the existing as object".)

speculative metaphysics, namely how 'autonomy' (alias 'autonomous unity') and 'determinacy' (or 'definiteness') indepently of cognition can be thought of together (in the light of the fact that determinacy logically implies distinction, which points to holism). This question can (from the 'physical' point of view, sketched above) also be interpreted in the sense of the question of the origin of the two components of our understanding of cognition, which epistemology presupposes as its premise, namely the 'determinacy' and the 'transcendence' of objects. The solution to these two questions cannot be found in the way of an 'objective' (descriptive) cognitive approach, which presupposes precisely that which needs to be explained, namely the 'determinacy' and the 'transcendence' of the phenomena in question. Rather, the solution only emerges when both are regarded as generic products of a development, namely (as indicated) from the perspective of the genesis of precariously autarkic ('living') units and their ontological status. It is their status of 'dependency' that leads out of the total immanence of the physical sphere (its 'blindness'). It brings into play a form of 'definiteness' that simply does not exist otherwise. See the opening quote by Erwin Schrödinger.

The paradigms of epistemology are in themselves the main obstacles to an adequate understanding of the transcendental (explanatory) cognitive concept of physics, which can however ultimately only prove to be a real alternative if this concept is also successfully applied to the phenomenon of 'cognition' (with all its phenomenological and logical aspects).

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