Pro-Fil 24 (2) 2023: 1–17
https://doi.org/10.5817/pf23-2-37364

EMERGENCE IN ONTIC STRUCTURAL REALISM

PETR DVOŘÁK

Sts. Cyril and Methodius Faculty of Theology, Palacky University, Olomouc, Czech Republic
petr.dvorak@upol.cz

RESEARCH PAPER ▪ SUBMITTED: 13/10/2023 ▪ ACCEPTED: 18/12/2023

Abstract: The paper outlines the understanding of emergence in Ontic Structural Realism of James Ladyman (and his co-author Ross). First, the notion of emergence is explored, surveying the various distinctions associated with it (ontological vs. epistemological, diachronic vs. synchronic, weak vs. strong). It turns out that Ross and Ladyman's notion of emergence is that of weak epistemological emergence compatible with ontic reduction. Particular notions of emergence are associated with the objection embodied in the Generalized Causal Exclusion Argument. The latter is sketched and the solution of Ross and Ladyman is presented: first, in general, the notion of weak emergence is not threatened by this objection. Causal reduction associated with it ensures that there are no competing causal explanations, so no overdetermination arises. Second, there is a peculiar feature of Ross and Ladyman's theory; namely, there is no causation on the fundamental level, only pattern dynamism. Causation emerges only on higher levels of special sciences. Hence, there is no problem of *causal* overdetermination.

Keywords: emergence; weak emergence; James Ladyman; Ontic Structural Realism; metaphysical structuralism

Emergence has been the topic of vigorous discussions in the philosophy of science as well as analytic metaphysics and the philosophy of mind for some time now. In the former questions revolve around the issues concerning special science objects, their ontological status and possible reduction to the objects of more fundamental sciences, as well as their causal and nomological roles. In the latter the main issues of contention concern existence and causal roles of emergent entities (objects and features).

In this paper we are interested in the overlap of both of these debates, namely, in the status of the objects of non-fundamental sciences, their causal interactions and relationships with the fundamental level entities. We shall see these issues through the lens of the generalized version of Kim's Causal Exclusion argument. The more specific goal will be to get some insight into how these problems are solved in Ross and Ladyman's Ontic Structural Realism (OSR), a naturalist metaphysical view put forth by its authors as derived from our best scientific explanations and consistent with contemporary scientific outlook, not some armchair *a priori* conceptual analysis. This brand of realism regards objects to be posterior to their relations. According to OSR, reality is structural at its core and the relationships are real even though the objects posited by various sciences might not be as they are prone to change as science evolves. These relational structures occur at different scales of scientific enquiry. Objects on one level are themselves structures on a deeper level and so on without there necessarily being some fundamental bottom level. The concept of emergence is a key to understanding the relationship of these various levels.

We shall observe that Ross and Ladyman subscribe to weak emergence of inferential and conceptual kinds even though the term "emergence" is missing in their account. Ross and Ladyman are right that there are many different conceptions of emergence in contemporary authors writing on the topic, but wrong that it cannot be given precise meaning. Notice their expression "hopeless jumble" in the following excerpt from their well-known book *Every Thing Must Go: Metaphysics Naturalized*:

> We … prefer a different label – 'scale relativity of ontology' – for the position, because 'emergent' and all its semantic kin have come to stand for a hopeless jumble of different ideas in different literatures, including popular ones (Ladyman, Ross 2007, 193).

Our inquiry falls into three parts (sections). First, we clarify what emergence is and the customary division into weak and strong version of it. We shall focus on weak emergence and especially the one associated with universality (multiple realizability) as this is the phenomenon on which Ross and Ladyman base their account of scale relativity and emergence of causal facts in special sciences. Second, the Generalized Causal Exclusion Argument is introduced and discussed and the response of Ladyman to the argument is given. Third, Ross and Ladyman's views on emergence of causal facts in special sciences and the associated concept of non-reducibility are discussed in view of A. Reutlinger's criticism.

1. Understanding the concept of emergence and its kinds

Even a cursory survey of the current literature on emergence reveals several things: First, emergence is in some sense opposed to reduction, i.e. the view that explanatorily or ontologically, there is *really* nothing over and above the laws, facts, entities, features, powers or interactions at the underlying (fundamental) level. One can thus speak about *autonomy* of sorts belonging to emergents. Yet, second, emergence involves a kind of *dependence* relation – whether it be inferential or ontological – of laws, entities, features, powers, or interactions of the higher-level on those of the lower-level. Emergence is thus opposed to dualism in which such a relation is not present. Third, as it is implicit in the formulations just given, there are at least two notions of emergence, an epistemic one and an ontological (metaphysical) one. Fourth, there appears to be a nearly universal agreement that there are two kinds of emergence, weak and strong. The latter but not the former involves the so-called downward (or top-down) causation of some kind, even though there is no agreement on classifying some examples of purported emergence in the philosophy of science such as quantum entanglement of two particles, universal phenomena in physics as well as the most discussed case of emergence in the philosophy of mind, that of the mental in relation to the bodily. While virtually everybody agrees that strong emergence is incompatible with reduction, there is difference of opinion on the issue whether weak emergence is compatible with reduction of some kind.

In the rest of this section, we shall investigate the details of the aforementioned four points starting with the latter two. The clarification of what kinds of emergence there are (points three and four) will shed light on the relationship between emergence and reduction (point one) and the nature of the dependence relationship (point two). Also, I will especially (but not exclusively) draw on two representative accounts of emergence in recent literature by Jessica Wilson and Paul Humphreys, both of whom – apart from a series of papers – devoted a comprehensive book-length study to the topic from a general philosophical perspective (Wilson 2015; Wilson 2021; Humphreys 2016).[1]

Generally put, emergence is a relational concept: something arises from something else but not vice versa. Also, nothing is emergent from itself. The relationship of emergence is thus taken as asymmetric and irreflexive.[2] Hence, there are two levels involved in emergence, a base or the fundamental/lower level and some emergent higher level. Also, the emergence relationship is some kind of dependence at its core. Now the question arises what are these levels and how is the associated dependence relationship to be understood? Do these levels amount to entities of sorts such as objects, properties (features), facts, interactions or processes, or do they involve something else, e.g. truths or laws? Is the dependence relationship that between things or statements? This seem to depend on whether the notion of emergence is cashed out in epistemological or ontological terms. Ontological or metaphysical emergence is a relationship between entities.[3] There are higher-level objects, properties or facts emerging from lower-level ones. The relationship between them is ontic dependence such as supervenience, constitution, a relationship of a realizer and the realized, causation and such like. In contrast, in epistemological emergence this dependence is some kind of inferential relationship, and the levels consist of statements: truths, laws, descriptions of facts and such like.

There could be further distinctions made under the rubric of "epistemological emergence". P. Humphreys differentiates *inferential* emergence from *conceptual* one.[4] The former concerns predictability. The issue is whether higher-level (descriptions of) facts could be derived from the lower-level ones plus lower-level rules, i.e. laws governing the lower-level. The latter has to do with the need to introduce new concepts and laws in which they would occur in order to describe the higher-level system behaviour in relation to the conceptual theoretical framework associated with the lower-level goings on. In this context J. Wilson speaks about *explanatory* emergence in contrast to *metaphysical* one. If the lower-level states or system dynamics are to explain the higher-level ones, then, arguably, there should be both: new patterns of description (new concepts and laws, i.e. what Humphreys calls conceptual emergence) as well as some kind of unpredictability, underivability (inferential emergence) of these.

In reference to the dependence relation found at the heart of metaphysical emergence one can make a distinction between *synchronic* and *diachronic* emergence. If the dependence of the higher-level on the lower is simultaneous (but not necessarily instantaneous), then what we get is synchronic emergence. While for J. Wilson all emergence is synchronic, for P. Humphreys the paradigm case of ontological emergence, fusion emergence, is diachronic.[5] In fusion emergence the lower-level properties merge into a new emergent property with its novel causal powers. For instance, in chemical covalent bonding (in contrast to ionic bonding) two atoms share a pair of electrons with the electron density being distributed over the entire molecule, not the two atoms.[6] This causes that some properties of the molecule are different from what they would be if a mere composition of the properties of the atoms occurred. The dependence relationship thus cannot be simultaneous (such as supervenience) for the lower-level properties

[1] Another study worth reading is Havlík (2021). There appeared an English version recently, Havlík (2022). The author of the present study did not have the English version at his disposal, so the page references are to the original Czech version.

[2] Commonly also non-transitive.

[3] While J. Wilson speaks about metaphysical emergence, P. Humphreys uses the term "ontological emergence".

[4] Even though Humphreys (2016, xx) equates inferential and epistemic emergence preferring the former term.

[5] For Wilson's dismissal of diachronic emergence cf. Wilson (2021, 8-10). For fusion emergence see Humphreys (2016, 70ff).

[6] For an important criticism of the view see Manafu (2015).

exist no more and neither do their causal powers. For Humphreys this is a clear reason for the rejection of what he calls generative atomism, the view that everything can be derived from lower-level "atoms" (basic entities of some type) which retain their identity, are countable (enumerable) and immutable, just using a set of lower-level rules.[7] In contrast, J. Wilson would treat such cases as synchronic emergence in which the lower-level "atoms" do not cease to exist, but their powers get restricted as they enter into the composition of the whole.[8] In what follows there is no need to pay too much attention to the distinction between synchronic and diachronic emergence. We can restrict ourselves to synchronic emergence only as our prime interest will be the realizer-realized kind of dependence present in the cases of universality in science as well as various kinds of inferential relationships (e.g. derivability).[9]

In the remaining part of the present section, we shall deal with the distinction between weak and strong emergence and the various characterizations of emergence in main authors working in the field. Let us begin with the question how does the previous distinction between metaphysical (ontological) and epistemological emergence relate to the present distinction pertaining to the strength of emergence? For some authors the former distinction cuts through the latter: A common opinion characterizes weak emergence as merely epistemological while strong emergence as ontological. This is the position of P. Humphreys (Humphreys 2016).[10] On the other hand, for J. Wilson both strong and weak emergence are metaphysical.[11] D. Chalmers characterizes both kinds of emergence, weak and strong, in epistemological (more specifically inferential) terms. Such a characterization does not preclude that at least strong emergence can be also regarded as a metaphysical phenomenon. Let us fill in the details of these models and understand the basics of how they work.

D. Chalmers speaks about emergent phenomena.[12] While strong emergence amounts to non-deducibility of higher-level truths from lower-level truths in principle, in weak emergence the truths of the higher-level are unexpected, difficult or impossible to derive in practice, but the derivation is not impossible as a matter of principle. In strong emergence higher-level truths are not necessitated conceptually or metaphysically by lower-level truths. Since the higher-level laws and the so-called bridge laws connecting the facts on both levels, are not deducible from those of the lower-level, the former two types of laws are no less fundamental as the latter.

This epistemological characterization of emergence has an ontological correlate: entities or properties belonging to the higher-level arise from those of the lower-level. In strong emergence the dependence relationship is that of global *nomological* supervenience:[13] For any two distinct possible worlds of the same class of nomologically identical worlds (worlds with equivalent laws), once the same lower-level facts in both worlds are in place, the same higher-level facts

[7] Ancient atomism of Democritus or Russell's logical atomism are prime examples of such a view. In contrast, P. Humphrey's views give some support to Aristotelian hylomorphism. See Humphreys (2016, 2-3; 11ff).
[8] In composing the whole there occurs some restriction of the degrees of freedom of the lower-level entities whose interactions ground their causal powers as J. Wilson would put it.
[9] We have seen that for Wilson emergence is synchronic and for Humphreys it is diachronic. But it seems that these do not have to be treated as exclusive: emergence has both dimensions as it is forcefully argued in Havlík (2021, 4.2., esp. p. 262ff).
[10] Cf. also Clayton (2006).
[11] V. Havlik regards both species of emergence as instances or manifestations of one general concept of emergence which is ontological, cf. Havlík (2021, 2.3.3, 149ff).
[12] For Chalmers, the only strongly emergent phenomena which exist in reality are arguably mental states, Chalmers (2006).
[13] For instance, J. Kim points to the incompatibility of strong emergence characterized as non-deducibility of higher-order properties from lower-level properties and laws with logical (metaphysical) supervenience. Cf. Kim (2009).

obtain as well. Nevertheless, it is conceivable and thus metaphysically possible that all lower-level facts are fixed without there being the appropriate higher-level facts. That is, two metaphysically possible worlds not belonging to the same class of nomologically identical worlds sharing all lower-level facts might differ as to higher-level facts. For instance, two individuals in two such nomologically distinct metaphysically possible worlds might share the same brain states but not mental states.[14] So the dependence relationship is modal in nature, it is characterized by some kind of necessity, in this case nomological necessity. In weak emergence the dependence relationship between lower-level and higher-level properties is that of *logical* (also called *metaphysical*) supervenience.[15] Instead of nomologically possible worlds one quantifies over all metaphysically possible worlds and there are no two metaphysically possible worlds sharing all the lower-level facts but not the higher-level ones. Here the necessity is broadly logical or metaphysical.[16]

P. Humphreys equates strong emergence with one type of ontological emergence. While the aforementioned fusion emergence is ontological, but does not include downward causation, strong emergence is ontological emergence with downward causation (Humphreys 2015, 137-152, esp. 139). What are the criteria for emergence in Humphreys? They are the following (Humphreys 2016, 26ff):

1. the existence of a novel property
2. fundamental bridge laws
3. emerging property belongs to the whole, not its parts (holism)
4. causal autonomy

By "the existence of a novel property" Humphreys means that in ontological emergence the emerging property of the whole is of a different kind from the properties of the parts. Mere redescription of the lower-level system dynamics is not enough. It is clear that sole conceptual emergence does not meet the criteria as there is no genuine new property over and above the properties of the parts (e.g. the properties of a flock of birds are ontologically reducible, i.e. are nothing over and above, the properties of the individual birds taken together). We have already mentioned that the phrase "fundamental bridge laws" points to the laws connecting the lower and higher-level phenomena and that these laws cannot be deduced from the lower-level ones. If they cannot be deduced, the relationship between the levels cannot be that of logical supervenience but only nomological one. Notice however, that Humphreys does not make supervenience part of the necessary criteria of emergence as he is predominately interested in diachronic emergence in which the dependence relationship is not synchronic (as in the case of fusion emergence) and that supervenience is a synchronic determining relationship.[17] "Causal autonomy" means that there is a causal power associated with the emerging feature of the whole distinct from the causal powers of its parts, and that in virtue of this new power it engages in

[14] This relates to Chalmers arguments for the metaphysical possibility of zombies, i.e. individuals with certain brain states but without the mental states which supervene on them in any world nomologically identical with ours, Chalmers, (1996, 94).
[15] For the distinction between global and local supervenience as well as the distinction of logical and nomological supervenience (the latter also called "natural" in Chalmers) see Chalmers (1996, 33-38).
[16] Metaphysical necessity is sometimes called broadly logical as it does not concern only formal logical truths such as "$p \vee \neg p$" in propositional logic but also conceptual truths - analytic statements or Kripkean *aposteriori* necessary truths if there are any ("water is H_2O"). For the notion of broad logical necessity see Plantinga (1974, 2).
[17] For instance, T. O'Connor has changed his mind on supervenience being a necessary condition of emergence at least in the case of mental states arising from bodily states. This is because he is now in favor of diachronic emergence in the latter case where the dependence relationship is that of causation. O'Connor (1994, 91-104), O'Connor (2000, 105-11).

new kinds of interactions. It is clear that if these criteria are taken as necessary conditions for there to be emergence, they pertain to strong emergence *only*.

Humphreys's characterization of weak emergence deepens the understanding of why it is *practically* impossible to derive the higher-level truths even though not impossible *in principle*. This practical impossibility is usually explained as the inability to carry out the derivation or computation for the sheer amount of computational capacity required to take account of the immensity of the lower-level goings on, the number of whose interactions grows exponentially. The lower-level processes are often sensitive to initial conditions (deterministic chaotic dynamics). Humphreys's explanation is based on the idea of algorithmic incompressibility (Humphreys 2008, 9:10-29:38). For instance, in order to predict a solar eclipse a hundred years from now one could use the laws of Newtonian mechanics without the necessity to compute all and every intermediate state from now on to the time of the predicted occurrence. Some events are not that easily predictable and one has to run a computational simulation taking into account all the states in the evolution of the system. The same idea is expressed by Mark Bedau characterizing weak emergence as derivability by simulation only.[18]

According to Humphreys, when one merely redescribes lower-level goings on at a higher-level through new concepts, for instance when higher-level wholes and their dynamics are generated by an application of a set of simple rules governing lower-level dynamics of the parts such as the dynamics of flocks of birds or glider guns in the famous Conway's Game of Life (which is a type of cellular automaton), these are examples of weak emergence which is only epistemic (the kind Humphreys calls conceptual).[19] Now according to Humphreys the flock does not exist, only the individual birds, so weak emergence is compatible with antirealism about higher-level entities. But if Chalmers is right that weak emergence involves the relation of logical supervenience, then the higher-level entities exist, even though they do not possess any causal powers over and above their lower-level base counterparts.[20] The former (Humphreys's treatment of weak emergence) implies ontic reduction, the latter (Chalmers's understanding of weak emergence) involves causal reduction. Both can be seen as species of explanatory reduction, even though sometimes explanatory reduction is equated with causal reduction only. When emergence is taken to be incompatible with reduction what it means is that weak emergence is incompatible with *ontic* reduction. "Non-reductive physicalism" is non-reductive in the ontic sense of "reduction", not a causal one.[21] As for strong emergence, the latter is incompatible with reduction in both senses.

According to Humphreys, weak emergence is compatible with what he calls generative atomism. The latter has analytic and synthetic aspects. Generative atomism understood as synthetic is what he calls a constructivist project, derivation of higher-level facts from lower-level ones; e.g. the derivation of an exact value of some quantitative higher-level predicate from the system's microdynamics. Understood analytically, it is a reductive explanation, i.e. higher-

[18] "Macrostate P of [the system] S with microdynamic D is weakly emergent iff P can be derived from D and S's external conditions but only by simulation. D is a microdynamic governing the time evolution of S's microstates" (Bedau, 1997, 4). A microstate of a given part of the system at a given time is a result of the microstates of surrounding parts of the system at preceding times. S's microstates are the intrinsic states of its parts, and its macrostates are structural properties constituted wholly out of its microstates.
[19] See simulation here: https://playgameoflife.com/ (Retrieved Dec. 30, 2021); cf. also Berto (2017). In relation to emergence cf. Bedau (1997). See also Havlik's analysis: he understands this emergence as ontological and even ascribes to higher-level entities causation of their own (Havlík 2021, 288).
[20] We take the relation of supervenience to imply the negation of ontic reduction here.
[21] We understand non-reductive physicalism to imply weak but not strong emergence of mental properties.

level phenomena are explained by reference to lower-level processes.[22] While reductive explanation might be possible, for instance of universal phenomena in physics such as thermodynamic properties of gases and fluids or ferromagnetism, based on the dynamics of the lower-level constituting particles, the constructivist enterprise is not possible as the critical behaviour of the system near the critical point (critical temperature) cannot be predicted from the lower-level goings on.[23]

If Chalmers is right that weak emergence involves the relation of logical supervenience, then weak emergence is not only epistemic, but metaphysical as well. This is exactly what J. Wilson thinks even though in order to present her position properly we would have to restrict or reinterpret the phrase "causal reduction" associated with weak emergence. This is because Wilson would reject epiphenomenalism, the view that the higher-level entities have no causal powers or are causally inert.

According to Wilson, both weak and strong emergence of features or entities are ontological, or, as she consistently says, metaphysical.[24] There are two necessary and jointly sufficient conditions of emergence:

1. there exists a material dependence relation between a higher-level feature and a lower-level base configurational feature

2. the emergent feature is ontologically and causally autonomous, i.e. it has ontological distinctness and distinct efficacy

First thing to notice is the dependence relation and its relata. (i) Wilson dubs it "material" in order to make it consistent with physicalism (or physical monism, according to which everything which exists is physical), i.e. to preclude the implication that the emergent higher-level features are not physical. There arises a question whether by including "physical" within the definition she does not at the same time preclude the possibility that the emergent features might be mental (where "mental" usually opposes "physical"). (ii) The core of the dependence relation is the modal relationship of supervenience which is at least nomologically necessary (in case of strong emergence) if not logically necessary. Here her account seems to broadly agree with Chalmers's. (iii) For Wilson unlike for many other emergentists the dependence relation is one to one rather than one to many.[25] In other words, it exists between two feature types which both belong to the same whole rather than between a type or token feature belonging to a whole and type/token features of the parts of the whole. For Wilson the base feature is itself configurational, i.e. a feature of the whole whose parts are in some configuration. So, the fact that there is a whole with a property which does not belong to any of its parts, or that there is a configurational feature of a whole resulting from the fact that the parts of the whole have certain properties, does not make the property or feature of the whole emergent. An emergent feature arises from some such base configurational feature under certain conditions, namely, that there appears to be some power distinct from the power associated with the configurational feature which implies (by the converse of Leibniz's law of the indiscernibility of identicals, i.e. if *x* and *y* differ in properties, they are not identical) that there are two

[22] Humphreys (2015); Humphreys (2016, 1.3, 12). Cf. also Havlík (2021, 1.3, 70ff).
[23] Explanation thus does not require derivability of higher-level facts.
[24] The following account is based on Wilson (2021).
[25] For example, Bedau speaks about microproperties of parts of a system and system's emergent macroproperty.

ontologically distinct features associated with the distinct powers.[26] Let us note in passing that Wilson appeals to an ontologically light-weight conception of causal powers that even a Humean might accept: the range of effects associated with an object having a certain feature. Powers are grounded in types of interactions into which the object having the feature enters.

The two types of emergence, weak and strong, differ only in the "distinctive efficacy" part of the second condition of emergence, in other words, in the understanding of causal autonomy. While the causal power associated with a strongly emergent higher-level feature is genuinely novel, i.e. the feature has a token power distinct from any token powers of the lower-level feature (or the token powers of the constituents of the system for that matter), a weakly emergent feature does not have a power distinct from the lower-level goings on, but only has a different power profile from the base feature. This means that it has a non-empty proper subset of token powers of the base. In other words, the token power of the emergent feature is identical with a subset of the token powers of the base. For Wilson this is sufficient to ground ontic distinctness of the emergent feature (again via the application of Leibniz's law as above).

Weak emergence is associated with functional accounts of higher-level predicates prompted by multiple realizability. Functionalism in the philosophy of mind takes mental predicates to refer to properties defined functionally in causal terms (sets of inputs are correlated with particular outputs).[27] Such functional properties are second order properties which could be realized by various first order properties. In other words, a functional state can have multiple realizers, different brain states in man as well as in different animals, differing in some lower-level details which are not relevant for the coarse-grained functional property. Such is the relation in some physical systems between the system's microproperties and its macroproperty. For instance, there are some macroproperties specifying a particular kind of behaviour near the critical point, an instance of the so-called universal phenomenon, in a wide range of fluids as well as magnetic substances (metals). These macroproperties arise from microproperties. However, since different microsystems exhibit the same macrobehavior, only some microproperties are relevant, i.e. foundational for such a macroproperty or global property of the system. These universal phenomena in physical systems on micro-macro levels are analogous to multiple realizability of mental states by physiologically different states of the nervous system. According to Wilson here the macroproperty or mental state has only a portion of causal powers identical with some powers of some microproperties or brain states.

There does not seem to be any doubt that strong emergence, if it existed, would be a metaphysical phenomenon as it postulates novel causal powers and hence (by Leibniz's law), distinct entities.[28] With Chalmers and Wilson we have interpreted weak emergence in metaphysical fashion, but this does not seem to be necessary as many interpret weak emergence solely in epistemic (inferential, semantic) terms. This ambiguity is arguably the reason why some take emergence to be the antithesis of (ontological) reduction and others do not. As we

[26] What is presupposed here is that both the base configurational feature as well as the emergent feature belong to the same whole. This *prima facie* excludes emergent objects. Wilson allows for this possibility but sees the emergence of features as primary.
[27] Here we in no way assume the truth of functionalism, i.e. that it is the correct explanation of the relationship between mental and physical. Nor we assume that Wilson or anybody else is a functionalist. Rather, we assume that if functionalism were correct, then it would be a case of weak emergence analyzed metaphysically in such and such terms.
[28] What we have said so far does not commit us to the view that there really are cases of strong emergence. All we have done so far is a mere conceptual analysis. Existential claims to the effect that there are cases of strong emergence would require further argument.

shall see, Ladyman and Ross are interested in weak emergence and take it as epistemic or explanatory relationship compatible with ontological reduction.[29]

2. The Generalized overdetermination argument

There is a famous argument against non-reductive physicalism in the philosophy of mind formulated by J. Kim called the "Causal Exclusion Argument".[30] The latter shows that it is impossible to be a physicalist, or, in general, maintain causal closure of the lower-level, i.e. of physical brain states, and ascribe distinct causal powers to higher-level properties supervening on lower-level ones at the same time, i.e. to mental states.[31] In order to avoid causal overdetermination (and still maintain the aforementioned causal closure and thus remain a physicalist), one has to reduce all causation to the lower level. The result is that the higher-level entities, mental states, are causally inert and excluded from playing any causal role (more specifically, the upshot is to adopt epiphenomenalism as the solution to the mind-body problem if one wishes to remain a *non-reductive* physicalist).

This argument can be generalized to any relationship of the entities and causal powers studied by a fundamental lower-level science and those studied by a special higher-level science, typically to fundamental branches of physics (high energy particle physics) in relation to non-fundamental branches of physics (e.g. thermodynamics), or physics in relation to a higher special science (e.g. chemistry), or, finally, to the relationship of two special sciences of which one is more fundamental than the other (e.g. chemistry in relation to biology). What is at stake is the following: if there is causal closure within the lower-level science, and the higher-level science entities are necessarily dependent on the lower level-ones, how can there be any causation on the higher level at all if we are to avoid causal overdetermination?

Kim's Generalized Causal Exclusion Argument finds the following set of propositions to be inconsistent (instead of "higher-level entities" I will speak of "special science entities" and I will replace the talk of "lower-level entities" by "fundamental science entities" thus restricting the problem to the relation of a special science to the fundamental one such as thermodynamics to atomic and molecular physics):

1. There are special science features, and they are associated with causal powers to produce other special science and/or fundamental science features (in other words, there are special science causal laws).
2. There exists causal closure on the fundamental level: Every fundamental science feature has a sufficient cause, a different fundamental science feature or features.
3. Every special science feature necessarily depends on some fundamental science feature.
4. There cannot be causal overdetermination: no effect can have two or more sufficient causes.

[29] An exchange between Ladyman and Wilson on this point is interesting. Wilson claims that (weak) emergence excludes reduction, Ladyman responds that for him reduction and emergence are compatible. To this claim Wilson replies that weak emergence is compatible with explanatory reduction (i.e. causal reduction in some sense), but not ontological reduction. Yet, I think, this exchange exhibits a deeper disagreement between the realist metaphysics of Wilson and the structural realism of Ladyman. Ladyman, by analyzing weak emergence only in epistemic terms, has no qualms with ontological reduction. Structural realism does not commit him to realism about special science entities, only their structural relationships. See Wilson's talk Wilson (2021b).
[30] Kim (1989).
[31] "Causal closure" within a level means that for any event on that level there is a sufficient cause (or causes) within the same level.

If by “special science features” one understands “mental states” and “fundamental science features” are taken to be physical states of the brain, one gets back the original Causal Exclusion Argument.[32] It is directed against the non-reductive physicalist, who is committed to holding 2 (because that follows from physicalism) and 3 (the supervenience relation is compatible with non-reductive stance; identity would not be so compatible, moreover, there must be either identity or dependence of the higher level on the lower physical level if physicalism is to be true). If the non-reductive physicalist is to avoid 4, causal overdetermination, the only chance is to reject 1, causal role of mental states. What are the alternatives?

Alternative 1: remain non-reductive physicalist and reject that mental and physical causes are two sufficient causes of the same effect, i.e. show that the set of propositions is not inconsistent after all.
Alternative 2: remain physicalist, but reject non-reductive stance, i.e. adopt anti-realism about mental states and thus reject 1 and 3.
Alternative 3: become property dualist and thus reject the closure principle 2.

Understanding special science features as strongly emergent is analogical to Alternative 3. The presence of downward causation and special causal powers is what makes this type of emergence strong.

It is clear that understanding the special science features as weakly emergent is akin either to Alternative 1 or Alternative 2. Strategy 1 (analogical to Alternative 1) is to interpret weak emergence in a metaphysical way and regard the emergent features as ontologically and causally distinct from their fundamental level counterparts yet show that there is no overdetermination after all. Strategy 2 (analogical to Alternative 2) is to treat weak emergence as epistemic only (as for instance what Humphreys calls “conceptual emergence”) and be antirealist about the existence of special science features.

J. Wilson adopts Strategy 1. In her theory there is no overdetermination because there is identity of powers in the sense that when a special science feature is exercising its causal power and simultaneously the underlying fundamental science feature is exercising its causal power, it is one and the same (token identity). So, in this sense there are not two sufficient causes of the lower-level effect, but only one. It is the distinctness of power profiles which grounds the ontic distinctness of the features.

Ross and Ladyman’s OSR in essence could be taken to adopt Strategy 2. Their structural realism is compatible with antirealism about higher-level entities. In fact, it is compatible with antirealism about entities on both levels, i.e. not only special science entities but also those of the fundamental science.[33] Besides this, Ladyman’s thought contains two other moves which

[32] The formulation of the Causal Exclusion Argument in the philosophy of mind typically includes a fifth statement in the set that mental states are not identical with the physical states of the brain. In our formulation, we do not have to include the statement that features treated in the special science are not identical with the features belonging to subject matter of the fundamental science as this is assumed implicitly.

[33] For Ladyman the dilemma of accepting higher-level entities into one’s ontology as entities over and above lower-level ones versus (ontologically) reducing higher-level entities to configurations of lower-level entities so that nothing would exist beside the latter is a false one (i.e. both options can be false). The third option is this: higher-level entities are real patters of lower-level entities existing only in dependence on an appropriate epistemological stand. The latter condition makes the view non-realist. It does not mean that higher-level entities are denied their being as in reductionism or eliminativism, but what is denied is their knowledge-independent ontological status. So, denying the realist option within the aforementioned dilemma does not automatically lead to the acceptance of the antirealist option of the dilemma. Thus, Ladyman is an antirealist in this special sense of

would each suffice to solve the Generalized Causal Exclusion Argument even without adopting Strategy 2: There is the idea that the apparent overdetermination arises due to a false, far too robust a notion of causation, that of a generative type, rather than a light-weight notion such as the Humean one or other.[34] There is also another move still without parallel in any of the alternatives already mentioned above. It consists in making lower-level (fundamental science) features causally inert rather than those on the higher level. This means denying proposition 2. Details of this move will be covered in the following section.

3. Emergent causal facts of special sciences in OSR

Ladyman and Ross adopt what can be called Neo-Russellianism about causation (Reutlinger 2017). There is no causation on the fundamental level and causal facts emerge only on the level of special sciences:

> Saying that special sciences furnish causal explanations, while fundamental physics aims at discovering universal laws, comes very close to the view we articulated in 5.4. Special sciences, according to us, use causal ideas as heuristics for locating real patterns. Fundamental physics is in the business of describing the structural properties of the whole universe. These properties are not causal relations. Special sciences and fundamental physics are thus mainly different from each other in a way we find it very natural to express by saying: fundamental physics aims at laws, whereas special sciences identify causal factors (Ladyman, Ross 2007, 286).

What kind of emergence is that? Ross and Ladyman recap Kim's criteria of emergence (Kim 1999). Out of the five criteria presented by Kim as each necessary and jointly sufficient they adopt two (again as each necessary and jointly sufficient for emergence):

> 3. The unpredictability of emergent properties: emergent properties are not predictable from exhaustive information concerning their 'basal conditions'. In contrast, resultant properties are predictable from lower-level information.
>
> 4. The unexplainability/irreducibility of emergent properties: emergent properties, unlike those that are merely resultant, are neither explainable nor reducible in terms of their basal conditions.

They explicitly reject Kim's criteria 1 and 2 stating the emergence of ontically distinct objects and properties and criterion 5 speaking of a novel causal power implying that emergent features possess downward causal efficacy.

It is clear that Ross and Ladyman wish to reject metaphysical emergence in favor of epistemological one. Also, the emergence at stake is only a weak one. There is no *sui generis* causal power. The unpredictability condition (3) is accordingly to be taken as practical unpredictability, not unpredictability in principle. What they have in mind is the unpredictability of universal facts involving macroproperties of fluids, gases and magnets concerning a system near its critical point pertaining to phase transitions from some lower-level facts involving microproperties, i.e. from the dynamics of individual particles composing the

---

the third option. Perhaps one should use the term non-realism and reserve the term "antirealism" for the denial of the ontic status of the higher-level entities *simpliciter*, cf. Ladyman (2009, 120-121). For the notion of causation favored by Ladyman cf. Spurrett, Ross (2003).

[34] Spurrett, Ross (2003), Ladyman (2008).

system. Here the unpredictability at stake concerns the way renormalization group (RG) methods work in science.

Now as for irreducibility, this is not to be taken as ontic irreducibility, but explanatory irreducibility consistent with ontic reducibility, i.e. compatible with antirealism about higher-level phenomena. This is to be understood in the following sense taken from R. Batterman (Batterman 2000, 2019) whose work is an important departure point for Ross and Ladyman: the same universal feature (e.g. a critical exponent found in gases as well as ferromagnetic metals) is realized by various microsystems with different dynamics. The universal feature is discovered by applying an RG method. RG method is a mathematical procedure, basically a successive calculation of the energy (the so-called Hamiltonian) of the entire system at a critical point in each step taking into account progressively more distant interactions between particles. This is done essentially by coarse-graining. The initial calculation of the Hamiltonian takes into account only interactions in immediately adjacent particles (in case of thermodynamic properties) or spin alignments of adjacent particles (in case of ferromagnetic properties). In the next step these latter interactions or alignments are given some average values over the region of adjacent particles and the average values of the adjacent regions are taken into consideration in calculating a value of yet larger region consisting of a particular region and its immediately adjacent regions. This procedure is iterated to the point that the Hamiltonian does not change any more. We say that a fixed point is reached in the flow of Hamiltonians. Any further iteration of the procedure would produce the same value of energy given by the Hamiltonian of the fixed point.[35] A Hamiltonian is a global parameter giving the energy of the entire system.

For thermodynamic properties the points are characterized by two parameters: (i) an order parameter given by the difference in densities each of which characterizes one phase of a substance both of which coexist at a certain temperature in the same system and (ii) temperature. Reaching the so-called critical point (certain temperature under certain pressure) at which the Hamiltonian of the system is being calculated as a part of the RG method procedure explained above, this order parameter takes the value zero which means that a phase transition has occurred and both phases are not present in the system any longer, just one phase. For ferromagnetic properties the points are also given by two parameters: (i) an order parameter expressing the number of particles with aligned magnetic moments (spin), i.e. magnetization, and (ii) temperature. And again, reaching a critical point means that after critical temperature is reached by the system, magnetization is not present (i.e. is zero). In both cases the order parameter decreases with temperature with certain power (some fraction). This is the so-called critical exponent which is the same for different substances in the case of phase transitions and different metals for ferromagnetic properties. Not only that, universality means much more: the critical exponent is the same for both kinds of phenomena, i.e. thermodynamic properties near the critical point as well as ferromagnetic properties.

One might observe that by successive calculations in the RG method some lower-level information is lost. Some microbehavioral interactional details pertaining to individual particles are filtered out as these do not ground the universal feature of the entire system. This is done

[35] See an analogical procedure of coarse-graining associated with the *Central Limit Theorem* in mathematical probability theory according to which if the sample size is sufficiently large, the sampling distribution of the mean for a variable approximates normal (Gaussian) distribution regardless of the original independent variable's distribution. The iterated procedure is the following: choose a sample of a particular size and calculate the mean of the sample. Thus, a distribution of sample means is found, i.e. the sampling distribution of the mean. Very different variable distributions at the outset lead to the same fixed point – normal distribution, when the procedure is applied.

iteratively to the point that the universal feature is discovered. The same macroscopic feature is discovered by this process even when one initially departs from very different microsystems, i.e. systems with differing microdynamics.

As we have seen, J. Wilson interprets weak emergence metaphysically. Would she interpret these universal macroscopic phenomena of physical systems realized by different microsystems as a case of weak emergence? The answer is affirmative as the key indicator of weak emergence (a necessary and sufficient condition) for Wilson is elimination of degrees of freedom in the transition from the description of lower-level phenomena to that of the higher-level phenomena.[36] As we have described the procedure (RG method), some degrees of freedom are eliminated. M. Morrison would also interpret universality as the case of emergence with ontological implications.[37]

Ross and Ladyman mirror Batterman's understanding of universal phenomena and the relationship of special sciences to fundamental science in general: no reduction is possible, because reduction requires derivability of higher-level features from lower-level ones. The possibility of explanation arising from the lower-level processes remains open, however, because for giving explanation one does not require reduction in the aforementioned sense.[38]

So, we have three senses of reduction already at play: (i) ontic reduction, (ii) explanatory reduction (in the sense of causal reduction) and (iii) inferential reduction (explanatory reduction in a stricter sense). This is how we are to understand the criteria 3 and 4 above used by Ross and Ladyman for emergence: in the case of special science entities and features, no inferential reduction is possible (unpredictability) and because of this the latter entities and features are non-reducible and inexplicable (in the sense of explanatory reduction in a stricter sense for which inferential reducibility is needed). This does not mean that the relevant explanation (explanatory reduction in the sense of causal reduction) is not compatible with such a view. It

[36] Wilson distinguishes *elimination* of degrees of freedom from *reduction* and *restriction* of degrees of freedom which do not constitute weak emergence. Reduction happens when e.g. one of the coordinates tracking position of a particle's trajectory is assigned a constant value (thus its movement is reduced from 3D to the plane). Restriction of degrees of freedom occurs e.g. when the range of possible behaviour of some particle is restricted as it enters some composition (becomes part of an atom or molecule). Cf. Wilson's talk (Wilson 2021b).

[37] Morrison describes the application and relevance of RG methods, her prime example of a higher-level phenomenon is superconductivity that arises from microbehavior of system's particles. She writes:
"Consequently, RG aptly illustrates the nature of the ontological relation between an emergent phenomenon/property and its microphysical constituents. As I noted above, epistemic independence—the fact that we need not appeal to micro phenomena to explain macro processes—is not sufficient for emergence since it is also a common feature of physical explanation across many systems and levels. Emergence is characterized by the fact that we cannot appeal to microstructures in explaining or predicting these phenomena despite their microphysical base. RG methods reveal the nature of this ontological independence by demonstrating the features of universality and how successive transformations give you a Hamiltonian for an ensemble that contains very different couplings from those that governed the initial ensemble" (Morrison 2012, 161).

[38] "My position regarding multiple realizations in the special sciences and reduction is somewhat unusual. If one holds a fairly standard philosophical view of reduction (some refinement of Nagel's model, e.g.), one can maintain that the multiple realizability of some special science property results in a failure of reduction. This much is not unusual. But on many (perhaps most) such views of reduction, to reduce is to explain. My position is unusual because it asserts the possibility of providing physical explanations for why certain special science properties are multiply realized without also providing a reduction..." (Batterman 2000, 134).

"Suppose we grant the commonly held view that a necessary condition for reducing a macrolevel property is the identification of some lower level physical property that is both necessary and sufficient for that macrolevel property. The RG type analyses I have been discussing fail to satisfy this necessary condition for reduction. This is simply because those analyses do not actually provide such properties, nor were they intended to." (Batterman 2000, 135) is and the explanation of the existence of universal features, i.e. of features realized by different realizers, is based on it. Also, such weak emergence is compatible with ontic reduction.

A. Reutlinger engages critically Ross and Ladyman's view of the emergence of causal facts of special sciences. He focuses on the explanation of universal special science features and the essence of his argument is the following: Ross and Ladyman treat special science features as emergent because they are non-reducible (a necessary condition for emergence). Yet, such features are reducible.[39] Hence, they are not emergent.

Now the view of reducibility that Reutlinger presupposes is that of (ii) explanatory reduction (in the sense of causal reduction). But we have seen that the notion of non-reducibility which is a criterion for emergence in Batterman and Ross and Ladyman is different: (iii) inferential irreducibility. Their view of emergence is compatible with explanatory reduction in the sense of (ii) and so is the view of Wilson. Wilson differs from the former authors by not understanding emergence as compatible with ontic reduction. Therefore, Reutlinger's criticism of Ross and Ladyman is in our view unjustified. But one has to be careful here, the sense of explanatory reduction with which Ross and Ladyman's view is compatible cannot be causal reduction in the strict sense because there is no causation on fundamental level! One has to understand causal reduction more broadly here, based on a concept which is more general and which can be interpreted as causation on one level and pattern dynamism on the other. Seen through the lens of Ross and Ladyman's theory, here the reduction is not to token causal powers of fundamental entities and features as Wilson has it, but to temporal micropattern dynamics which constitutes processes on the fundamental level.

Let us sum up our findings: Ross and Ladyman are right in claiming that there are different conceptions of emergence. But one can make sense of the various models quite easily so there is no reason to avoid the concept and use other terms such as "scale relativity". The disagreement concerns the nature of weak emergence, whether it is epistemic only (inferential, conceptual), or whether it necessarily has metaphysical interpretation as in J. Wilson. Ross and Ladyman accept the former. Their view of emergence is reduced to weak inferential emergence compatible with ontic reduction. They have no problem with the Generalized Causal Exclusion Argument on several counts. Their notion of weak emergence is compatible with explanatory reduction in the sense analogical to causal reduction.

[39] "RG explanations are reductive in the simple sense introduced in Sect. 1: a reductive explanation allows us to derive the explanandum (for instance, why fluid F and magnet M exhibit the same critical behavior, represented by the critical exponent) from information about the components of fluid F and magnet M. To see why, let me show that all three steps of an RG explanation appeal to the components of systems undergoing phase transition. The first step deals with representations (that is, Hamiltonians) of large systems of interacting components. It is characteristic of the relevant Hamiltonians that they describe the components of systems undergoing phase transitions such that each component of such a system does not merely interact with its nearby neighbors but also with distant components. The second step is concerned with transformations of these representations. Transformed Hamiltonians describe systems with reduced degrees of freedom, but the Hamiltonians nonetheless describe interactions between the components of liquids and magnets. The third step finally tells us why systems with different initial Hamiltonians show the same macro behavior: if the Hamiltonians representing, say, fluid F and F* turn out to "flow" to the same fixed point, then their behavior, when undergoing phase transition, is characterized by the same critical exponent. The second and the third step allow us to ignore details about the interactions, but ignoring details does not amount to the fact that interactions among the components do not matter at all and the associated Hamiltonians are not explanatory. It is a more accurate interpretation to say that RG methods show that universality depends on few details about the interactions among components." (Reutlinger 2017, 10)

Acknowledgements

The paper is an outcome of the Czech Science Foundation grant project no. 21-25233S *Structure in the Cambridge Group Social Ontology* carried out between 2021-2023.

References

Batterman, R. W. (2000): Multiple Realizability and Universality, *The British Journal for the Philosophy of Science* 51(1), 115-145, available at: < jstor.org/stable/3541751>.

Batterman, R. W. (2019): Universality and RG Explanations, *Perspectives on Science* 27(1), 26-47, available at: < https://philsci-archive.pitt.edu/13460/ >.

Bedau, M. A. (1997): Weak Emergence, in Tomberlin, J. (ed.) *Philosophical Perspectives: Mind, Causation, and World*, Blackwell, Malden, MA: Blackwell, 375-399, available at: <http://people.reed.edu/~mab/papers/weak.emergence.pdf>.

Berto, F. – Tagliabue, J. (2012): Cellular Automata, in Zalta, E. (ed) *The Stanford Encyclopedia of Philosophy* [online], 2012-03-26, rev. 2017-08-22 [accessed 2021-12-30], available at <plato.stanford.edu/entries/cellular-automata/>.

Clayton, P. (2006): Conceptual Foundations of Emergence Theory, in Davies, P. – Clayton, P. (eds.) *The Re-Emergence of Emergence: The Emergentist Hypothesis From Science to Religion*, Oxford: Oxford University Press, 1-31.

Havlík, V. (2022): *Hierarchical Emergent Ontology and the Universal Principle of Emergence*, Cham: Springer.

Havlík, V. (2021): *Hierarchická emergentní ontologie a univerzální princip emergence*, Praha: Filosofia.

Humphreys, P. (2016): *Emergence: A Philosophical Account*. Oxford: Oxford University Press.

Humphreys, P. (2015): More is Different…Sometimes: Ising Models, Emergence, and Undecidability, in Falkenburg, B. – Morrison, M. (eds.) *Why More Is Different: Philosophical Issues in Condensed Matter Physics and Complex Systems*. The Frontiers Collection. Berlin – Heidelberg: Springer.

Humphreys, P. (2008): Some Philosophical Consequences of Emergence, Lecture at Chicago Humanities Festival [online], 2008-10-11, [accessed 2021-12-30], available at: <https://www.youtube.com/watch?v=usdT9FtUSAs&t=880s>.

Chalmers, D. J. (2006): Strong and Weak Emergence, in Davies, P. – Clayton, P. (eds.) *The Re-Emergence of Emergence: The Emergentist Hypothesis From Science to Religion*, Oxford: Oxford University Press, 244-254.

Chalmers, D. J. (1996): *The Conscious Mind: In Search of a Fundamental Theory*, Oxford: Oxford University Press.

Kim, J. (2009): ‘Supervenient and yet not Deducible’: Is There a Coherent Concept of Ontological Emergence?, in Hieke, A. – Leitgeb, H. (eds.) *Reduction: Between the Mind and the Brain*, Heusenstamm: Ontos Verlag, 54–72.

Kim, J. (1999): Making sense of emergence, *Philosophical Studies* 95, 3–36, available at: <jstor.org/stable/4320946 >.

Kim, J. (1989): The Myth of Nonreductive Materialism, *Proceedings and Addresses of the American Philosophical Association* 63(3), 1989, 31–47, available at: <jstor.org/stable/3130081>.

Ladyman, J. (2009): Weak Physicalism and Special Science Ontology, in Hieke A. – Leitgeb H. (eds.) *Reduction, Abstraction, Analysis*, Heusenstamm: Ontos Verlag, 114-125.

Ladyman, J. (2008): Structural Realism and the Relationship between the Special Sciences and Physics, in Bicchieri, C. – Alexander J. (eds.) *Philosophy of Science* 75(5), Proceedings of the 2006 Biennial Meeting of the Philosophy of Science Association, 744-755.

Ladyman, J. – Ross, D. (2007): *Every Thing Must Go: Metaphysics Naturalized*, Oxford: Oxford University Press.

Manafu, A. (2015): The Prospects for Fusion Emergence, in Pârvu I. – Sandu G. – Toader, I. D. (eds.) *Boston Studies in the Philosophy and History of Science* 313, New York: Springer, 221-235.

Morrison, M. (2012): Emergent Physics and Micro-Ontology, *Philosophy of Science* 79(1), 141-166, available at: < jstor.org/stable/10.1086/663240>.

O’Connor, T. (2000): Causality, Mind, and Free Will, *Philosophical Perspectives*, 14, *Action and Freedom*, 105-11, available at: < jstor.org/stable/2676124>.

O’Connor, T. (1994): Emergent Properties, *American Philosophical Quarterly* 31(2), 91-104, available at: <https://toconnor.org/wp-content/uploads/2018/05/OConnor_Emergent-Properties-1994.pdf>.

Plantinga A. (1974): *The Nature of Necessity*, Oxford: Oxford University Press.

Reutlinger, A. (2017): Are causal facts really explanatorily emergent? Ladyman and Ross on higher-level causal facts and renormalization group explanation, *Synthese*, 194 (7), 2291-2305, available at: < philsci-archive.pitt.edu/10897/>.

Spurrett, D. – Ross, D. (2003): Three ways of worrying about 'causation', *ResearchGate* [online], [accessed 2021-12 30], available at: <https://www.researchgate.net/publication/36444126_Three_ways_of_worrying_about_'causation'>.

Wilson, J. M. (2015): Metaphysical emergence: Weak and Strong, in Bigaj T. – Christian Wuthrich, C. (eds.) *Metaphysics in Contemporary Physics*, Poznan Studies in the Philosophy of the Sciences and the Humanities 104, Leiden – Boston: Brill – Rodopi, 251-306.

Wilson, J. M. (2021): *Metaphysical Emergence*, Oxford: Oxford University Press.

Wilson, J. M. (2021b): Metaphysical Emergence in Complex Systems, at the Workshop of the Reading Group 'Foundations of Quantum Mechanics' Institut Néel (CNRS - Grenoble) [online], 2021-06-18, [accessed 2021-12-30], available at: <https://www.youtube.com/watch?v=kT4lfKj1YUg&t=1757s >.