

Real *ceteris paribus* Laws*

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1. Introduction

Although there is an ongoing controversy in philosophy of science about so called *ceteris paribus* laws—that is, roughly, about laws with exceptions—a fundamental question about those laws has been neglected (§2). This is due to the fact that this question becomes apparent only if two different readings of *ceteris paribus* clauses in laws have been separated.

The first reading of *ceteris paribus* clauses, which I will call the epistemic reading, covers applications of laws: predictions, for example, might go wrong because we do not know all the relevant factors which are causally effective in relevant situation. The second reading, which I will call the metaphysical reading, is concerned with the laws themselves and their possible exceptions (§3). It is this latter reading—and the fundamental question associated with it—which has been neglected due to the confusion of the two readings (§4): if we leave epistemic issues aside is there at all conceptual space left for a notion of laws of nature which allows the laws themselves to have exceptions? I call a law with exceptions in this sense, if such there is, a *real ceteris paribus law*.

To tackle this question, I distinguish grounded laws from non-grounded laws (§5). A grounded law is, roughly, a law about structured entities where the properties of the parts of that structure figure themselves in laws of nature (§6). I will claim that, since the substructure of such an entity can be damaged, grounded laws themselves can face exceptions. Hence, they are candidates to be real (metaphysical) *ceteris paribus* laws in the sense of my central question. I will discuss grounded laws and their exceptions in detail (§7, §8, §9).

For reasons of space, the further question whether we can even have a notion of fundamental (non-grounded) laws that allows for exceptions cannot be discussed here. I will, however, give a positive answer and also outline how I have argued for that claim elsewhere (§10).

2. Standard Stories about *ceteris paribus* Laws

Many philosophers of science think that most laws of nature are so called *ceteris paribus* laws; laws which hold in certain normal or ideal conditions only and are, hence, not strict:

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Nancy Cartwright: “All laws are *ceteris paribus* laws. (In Fn. :) I even intend to include most so-called fundamental laws of physics.” (Cartwright 1995: 155)

Pietroski and Rey: “Given current science, the appropriate question would seem to be whether any laws are strict.” (Pietroski and Rey 1995: 88)

The notion ‘*ceteris paribus*’—literally ‘all else being equal’—is usually read in a broad sense; namely, that a *ceteris paribus* law is a law which sometimes has exceptions. I adopt this broad reading. It should be mentioned, however, that it would be better to speak more generally of *proviso laws* if we have this broad sense in mind and of *ceteris paribus* only if we really mean that something, circumstances for example, have to be equal to a certain standard. Anyway, disregarding these verbal issues my focus will be on alleged laws which, in some cases, do not hold good, i.e., on laws for which some *prima facie* falsifications are just a exceptions.

An example which is often quoted by the proponents of *ceteris paribus* laws like Nancy Cartwright is Newton’s law of gravitation. It says that masses m attract other masses M at distance r with the gravitational force $F_G = GmM/r^2$. Let’s consider the special case of the earth and an arbitrary massive object near its surface, an overhead transparency for example. If we let it drop, will it fall according to the equation for the motion derived directly from the law of gravitation? It won’t. There can be all sorts of interferences: air resistance, the blowing of the overhead projector’s fan, electromagnetic forces due to electrostatic charge of the plastic, etc. So, even the prototype of lawhood—the law of gravitation—seems to be a *ceteris paribus* law:

The force of size GmM/r^2 does not appear to be there; it is not what standard measurements generally reveal; and the effects we are entitled to expect – principally an acceleration in a system of mass m a distance r away of size GM/r^2 – are not there either. (Cartwright 2002: 428)

However, this story is confusing and my aim is to attract attention to the fact that there are two different ways in which we can interpret the phenomenon that a law is a *ceteris paribus* law, i.e., a law with exceptions. Newton’s law of gravitation will, in the light of these new readings, be rehabilitated.¹

3. Two Readings of the *ceteris paribus* Clause

Reconsider the falling transparency. I said that Newton’s law of gravitation— $F_G = GmMr^{-2}$ —is a *ceteris paribus* law because, apparently, the transparency does not fall according to how the law says it should fall. This, however, was deceitful of me. What needs the proviso in this case is obviously not Newton’s law but our prediction only. Suppose we take other facts and laws on board, laws about air resistance, laws

¹ Newton’s law of gravitation is, of course, not a law at all. The law statement is false because of general relativity. I will use it nonetheless as my example. The reader can exchange it with any law statement he or she thinks picks out a real law.

about electro-magnetic forces, etc., facts about the charge the transparency is carrying, about the distribution of molecules in the air, etc.² then our prediction would be more and more accurate. While taking these laws on board, however, we do not suppose that Newton's law has changed (to $F_G = \frac{1}{2}GmM^5r$, say). Newton's law contributes to the falling of massive objects always the same force whether there are other forces around or not. Hence, it is not Newton's law which is a *ceteris paribus* law but it is our prediction which needs that proviso. The exception was only an apparent exception, not a real one. The law's effect was there in its full impact but it had been diluted or masked by other laws' effects which have also had a say in this particular scenario.

In short, if someone says a law *L* is a *ceteris paribus* law we have to ask whether she really means that, in many cases, an event is not entirely covered and hence not describable by just this single law but only by many—this is what I call the epistemic reading—or whether she indeed means that the law itself does not apply in this situation—which is the metaphysical reading. In this paper I want to focus on the latter reading. That is, I want to ask the question whether we can have a concept of laws of nature that allows the laws themselves (not only our predictions) to have exceptions.³

4. The Danger to Fail to Differentiate between the Epistemic and the Metaphysical Case

The danger to confuse the metaphysical case with the epistemic one is real. Poincaré, for example, comes to the conclusion that the laws themselves are only approximate although his example is an instance of a prediction which needs the proviso:

Take the law of gravitation, which is the least imperfect of all known laws. [...] I announce, then, with a quasi-certitude that the coordinates of Saturn at such and such hour will be comprised between such and such limits. Yet is that certainty absolute? Could there not exist in the universe some gigantic mass, much greater than that of all the known stars and whose action could make itself felt at great distance? That mass might be animated by a colossal velocity [...] it might come all at once to pass near us. Surely it would produce in our solar system enormous perturbations that we have not foreseen. [...] For all these reasons, no particular law will ever be more than approximate and probable. (Poincaré 1958: 130)

Or reconsider Pietroski and Rey's remark: "Given current science, the appropriate question would seem to be whether any laws are strict." (Pietroski and Rey 1995: 88) Why is

² Which is a utopian dream. But I take it that at least the following statement is a truism: the more we know the better we predict.

³ Next to my two readings of the *ceteris paribus* clause—the epistemic vs. the metaphysical reading—there is a second, similar, way to tackle the *ceteris paribus* issue: dispositionalists, like Nancy Cartwright (cf. Cartwright 1983, 1989, 1999) claim to be able to "strictify" laws like Newton's law of gravitation by claiming that they are not about the occurrent behaviour of objects but about their dispositions to behave. In "Can Capacities rescue us from *Ceteris paribus* Laws?" (Schrenk, forthcoming) I have pointed out that this strategy does more harm to an understanding of the *ceteris paribus* issue rather than that it enlightens the subject.

this so? Because current science has not yet found the real laws and has only law hypotheses which barely say what really happens in the world? Or is it rather because we have found the real laws but they are, indeed, *ceteris paribus*? Or is the confusion of an epistemic and an metaphysical issue at work as I am inclined to believe? Then Pietroski and Rey's remark is caused and motivated by the observation that predictions almost always go wrong where they then blame the laws for this failure. Consider a second of their remarks:

We want to say, recall, that the law of gravity holds, other things being equal. But other things are not equal when protons and electrons are the bodies in question, since these bodies also have charge. (Pietroski and Rey 1995: 105)

I am inclined to ask which law or relation it is then, if not Newton's law, that holds between a mass and a force in case there are charges around as well. Again, I suggest that it is a prediction which is purely based on Newton's law which goes wrong rather than it being the law which faces an exception.⁴

Apparently, the confusion between a metaphysical reading of the *ceteris paribus* clause and an epistemic one has led many philosophers to the wrong conclusion that laws like the law of gravitation are *ceteris paribus* laws. Philosophers who implicitly favour the epistemic reading of *ceteris paribus* tell us that all laws (now, wrongly, metaphysically speaking) are *ceteris paribus* laws. Generations of philosophers and scientists, however, have unquestionably presupposed that "laws of nature, whatever else they might be, are at least exceptionless regularities" (Lewis 1986: xi).⁵ The Oxford Dictionary of Physics, for example, states that "any exceptional event that did not comply with the law would require the existing law to be discarded or would have to be described as a miracle" (OUP 2000: 260).

No one, however, has questioned this creed and has taken the effort to inquire whether real exceptions to laws are conceptually or metaphysically possible.

5. The Distinction between Grounded Laws and non-grounded Laws

In order to start this inquiry it is necessary to divide the realm of laws into what I will call *grounded* and *non-grounded* laws. I will claim that both grounded laws and non-

⁴ My account bears some similarities to Hempel's in his (Hempel 1988): "Note that a proviso as here understood is not a clause that can be attached to a theory as a whole and vouchsafe its deductive potency [...] Rather, a proviso has to be conceived as a clause that pertains to some particular application of a given theory." (Hempel 1988, 26; my italics). Also consider Earman and Roberts' interpretation of Hempel's remark: "Hempel's provisos are not provisos proper but are simply conditions of application of a theory which is intended to state lawlike generalizations that hold without qualification. [Provisos] must be attached to applications of a theory rather than to law statements." (Earman and Roberts 1999: 444)

⁵ That Lewis himself is not quite that strict will be pointed out later.

grounded (or fundamental) laws can be laws with exceptions—although both in a different way.

The idea of groundedness is, roughly, that laws might be about complex objects. A law *Fs are Gs* is grounded iff *Fs* are objects with parts and a substructure such that the object's being *F* and its being *G* both supervene on the properties and relations of its parts and, moreover, the law *Fs are Gs* supervenes on the laws amongst the properties and relations of the parts of the object.⁶

If you influence the underlying structure of a particular *F* you perhaps influence the behaviour potential of this object and so you might challenge the validity of the law. I take grounded laws to be, in this respect, similar to dispositions with bases. If an object loses the basis for a disposition it also loses that disposition. If the ground for the grounded law is lost, so is the grounded law. Take laws governing the chemical reaction between complex molecules. If you could change the laws of atomic physics and / or you could modify the structure of the molecules you would change the laws applicable to that molecule.

A law *Fs are Gs* is *non-grounded*, on the other hand, if objects that are *F* do not have a substructure, or, at least, that substructure does not dictate whether the object is *F*, or *G*, or whether *Fs are Gs* holds. The fundamental laws of physics are most likely non-grounded laws in this sense.

6. Grounded Laws: the Accurate Definition

My ultimate definition of groundedness comes in three stages:⁷ (GL1) postulating underlying structures, (GL2) securing that the grounded law inherits the law character from the laws it is grounded in, and (GL3) making exceptions possible (but not inevitable) due to object internal structure changes.⁸

A law *L: Fs are Gs* is **grounded** iff:

(GL1) Postulating underlying structures.

For each *x* that is *F* there are C_1-C_n such that *x* is a mereological sum of C_1-C_n ($n = n(x)$)⁹. There are various properties and relations P_1-P_m , $P_1^*-P_h^*$ such that various C_i , and various composites of subsets of $\{C_1-C_n\}$ can have those properties and relations P_1-P_m , $P_1^*-P_h^*$ (with $m = m(x)$, $h = h(x)$), e.g. $P_1(C_1)$, $P_2(C_1 + C_3)$, $P_3^*(C_4, C_7 + C_3)$. There are laws L_1-L_k amongst the various P_i and P_j^* .

⁶ If the term “derived law” is more familiar the reader is invited to substitute “grounded” for “derived”. The reason I have chosen a new word is that I aim to underline the metaphysical aspect of my inquiry.

⁷ A health warning: the definition is formal and complex but it is only in this way that some wanted and unwanted consequences of grounded laws become apparent (§7, §8).

⁸ Just a note in advance: grounded laws are not necessarily laws with exceptions.

⁹ I.e., the number of parts varies per *x*.

A grounded law *Fs are Gs* is a law about complex objects x .¹⁰ Note that F s might be multiply realisable such that different x s which are F s have a different number and a different kind of parts. The parts C_1 – C_n need not be atoms; they can have parts themselves.

(GL2) Securing that the grounded law inherits the law character from the laws it is grounded in.

Consider the following domain $D := \{\text{the } x\text{s}; \text{ all the parts of the } x\text{s}\}$. F , G , and P_1 – P_m ¹¹ are defined on D , i.e., they are subsets of D , D^2 , D^3 , ... (It follows from (GL1)'s requirement that the P_j s obey some laws L_1 – L_k that not all logically possible P_1 – P_m distributions are allowed.) On D , the set of properties $\{F, G\}$ supervenes on the set of all the P_j s $\{P_j\}$ in the following way: for all x_1 and x_2 with parts $x_1 = C_1 + \dots + C_{n(x_1)}$ and $x_2 = C_1' + \dots + C_{n(x_2)}$: if there is a total match for all P_i between $\langle C_1, \dots, C_{n(x_1)} \rangle$ and some permutation of $\langle C_1', \dots, C_{n(x_2)} \rangle$ then $Fx_1 \equiv Fx_2$ and $Gx_1 \equiv Gx_2$ and (because of the laws amongst the P_j) $\forall x (Fx \supset Gx)$.

(GL2) ensures that the properties F and G supervene on the P_j properties which are properties of the parts of objects that are F s or G s and *en passant* that the grounded law *Fs are Gs* supervenes on the laws amongst the P_j .

So far, however, every loss of G -ness leads immediately to a loss of F -ness. That is not a disadvantage *per se*, but that means that so far our grounded laws are strict as long as the subvenient laws do not change. However, I am not asking for the laws which are *grounding* the grounded laws to be strict.¹² If the former are not, it is likely that the respective grounded law is not either. Yet, I want it to be possible for grounded laws to be *ceteris paribus* in two ways: one, where the underlying laws have exceptions *and*, two, where the underlying structure breaks down. For a grounded law to be a *ceteris paribus* law in virtue of the object's structure breaking down we have to allow for the possibility that an object is not a G while being an F without the underlying laws having changed.

This possibility opens up when we claim that (GL2) defines only sufficient (but not necessary) conditions for things being F s and G s. We can claim that there can be other sufficient underlying structures for F s and G s with other properties P_1^* – P_h^* than those in (GL2). P_i (of (GL2)) could be, for example, the property of having a certain mass or charge or volume whereas P_i^* is the property of having a little less or more mass, charge, or volume. An F whose parts change in this manner (from being P_i to being P_i^* ; from weighing 5g to weighing 5.5g) could still be an F , yet lose the property G .¹³ Hence point (GL3):

¹⁰ Please note that there are, of course, many different ways in which macroscopic objects can be cut into pieces but that does not matter for my definition. All I am saying is that if there is a way that fulfils (GL1)–(GL3) the law *Fs are Gs* is a grounded law.

¹¹ Note that I am only talking about the properties P_1 – P_m here and not yet about the other P_1^* – P_h^* I mentioned in (1). It will become clear in (3) why.

¹² Chemical laws, although they are themselves grounded and bear *ceteris paribus* clauses ground biological laws.

¹³ There can, however, be changes amongst the parts of an F which do neither affect its being F , nor its being G .

(GL3) Making exceptions possible due to internal structural changes.

Consider, again, the following domain $D := \{\text{the } xs; \text{ all the parts of the } xs\}$. F , G , and P_1 – P_m , P_1^* – P_k^* are defined on D , i.e., they are subsets of D , D^2 , D^3 , ... On D , the set of properties $\{F, G\}$ supervenes on the set of all the P_i s and P_j^* s $\{P_j^*, P_i\}$ in the following way: for all x_1 and x_2 with parts $x_1 = C_1 + \dots + C_{n(x_1)}$ and $x_2 = C_1' + \dots + C_{n(x_2)}'$: if there is a total match for all P_i , P_j^* between $\langle C_1, \dots, C_{n(x_1)} \rangle$ and some permutation of $\langle C_1', \dots, C_{n(x_2)'} \rangle$ then $Fx_1 \equiv Fx_2$ and $Gx_1 \equiv Gx_2$ and yet (note the difference to (GL2) making exceptions possible:) $\neg \forall x (Fx \supset Gx)$ (which is not to say that $\neg \exists x (Fx \wedge Gx)$).

7. An Example Grounded Law

Let me give an example of a grounded law to exemplify (GL1)–(GL3). The law I want to consider stems from biochemistry. To supply their cells with a continuous and adequate flow of oxygen vertebrates use two oxygen-carrying molecules: the proteins *haemoglobin* and *myoglobin*. Haemoglobin carries oxygen in blood, myoglobin facilitates the transport of oxygen in muscles. I focus on haemoglobin which shall be the main actor in the following example of a grounded law: oxygen (O_2) combines with haemoglobin (Hb) to form oxyhaemoglobin (HbO_2): $O_2 + Hb \rightarrow HbO_2$.

What corresponds to F , G , and the various P s in my definition of a grounded law now? Everything in front of the arrow corresponds to F , everything behind to G . That means particularly that F does not have to refer to a single object. An F can well be the complex body formed by the two molecules Hb and O_2 in a close enough spatial relation (if liquids, energy, movement, pressure, etc. are needed to kick off the reaction then F also refers to them). Since F s are chopped up into parts C_1 – C_n anyway, this move is of no great significance. G corresponds to HbO_2 but if there are any by-products next to HbO_2 G refers also to those by-products.

I should confess at this point that it might be necessary to reformulate the definition of a grounded law by replacing *Fs are Gs* by *if there is an F there is a G* (or $\forall x (Fx \supset Gx)$ by $\forall x (Fx \supset \exists y(Gy))$) and making the relevant adjustments in the rest of the definition. This is because the object which acquires the property G due to the law might not be identical to the object which is F . Likewise, a time variable might have to be incorporated for grounded laws which govern causal processes in time. It is also possible (or necessary) to talk about events rather than objects as suggested by my formulations so far. Those events would then include not only the main actors (that is the objects the xs in the definition seemed first to range over) but the whole space-time region and its properties where these objects are located.¹⁴

Here are some parts C_1 – C_n and some of their properties and relations P_1 – P_m , P_1^* – P_h^* towards each other: from biochemistry textbooks we learn that “the capacity of [...] haemoglobin to bind oxygen depends on the presence of a nonpolypeptide unit, namely, a *heme group*. [...] The heme consists of an organic part and an iron atom.” (Stryer

¹⁴ Hence, such an F event might be an object F_1 bumping into an object F_2 with such and such impulse surrounded by oxygen and G might be the event of an explosion.

1988: 144) In more detail, the heme group is a complex web of various carbohydrate chains and nets. In the middle sits, surrounded by four nitrogen atoms, the iron atom. Next to the internal bonds to the nitrogen the iron can form the crucial loose association with oxygen.¹⁵ Needless to say, the huge rest of the molecule has also a say in the character of this O₂ binding. There are four heme groups in total in each Hb molecule such that four O₂ molecules can be bound in total. In fact, the Hb molecule has the exciting feature to bind additional O₂ better the more O₂ has been bound already.

So far, I have only explicitly mentioned properties and relations P_1 – P_m , P_1^* – P_h^* amongst the parts but no laws. The relevant ones are, for example, the chemical or physical laws governing the bonding between O₂ and Fe and the rest of the molecule's subparts. Quantum mechanical laws tell us about these bondings. Therefore, I claim that the abstract (GL1) and (GL2) of my definition of grounded laws have found their real life counterparts. How about (GL3)? In order to make (GL3) plausible it is valuable to note that “the discovery of mutant haemoglobins has revealed that diseases can arise from a change of a single amino acid in a protein. The concept of molecular disease [...] came from studies of the abnormal haemoglobin causing sickle-cell anemia.” (Stryer 1988: 143–144) An easier example for the structural change I need for definition item (GL3) is, however, yet another derivative of the normal haemoglobin A: in haemoglobin M a

defective subunit cannot bind oxygen because of a structural change near the heme that directly affects oxygen binding. [...] Substitution of tyrosine for the proximal histidine results in the formation of a haemoglobin M. The negatively charged oxygen atom of tyrosine is coordinated to the iron atom, which is in the ferric state. Water rather than O₂ is bound at the sixth coordination position. (Stryer 1988: 170; the second part of this quote is to be found in the margin of the page as subtitle to figure 7–54)

Hence, we have an example of a haemoglobin (Hb) realiser (i.e., haemoglobin *M*) which does not combine with oxygen (O₂) to oxyhaemoglobin (HbO₂) (translated into (GL3): haemoglobin M is realised by the P_j^* properties which lead to $\neg\forall x (Fx \supset Gx)$). The grounded law has a real, not only an apparent, exception. The law's effect, Hb binding O₂ is not just covered haemoglobin M really does not bind O₂.

8. Grounded Laws: Challenges

There are challenges to the idea of grounded laws. In fact, it might be a matter of taste whether we accept them as laws or not. I want to discuss three problems:

(i) Are grounded laws laws? I will give three answers: *Answer 1*: lie down with the dogs get up with fleas. Grounded laws inherit their law character from the underlying laws. This answer is backed up by the fact that there could, in principle, be strict

¹⁵ “Each haemoglobin molecule contains 4 polypeptide chains, and each chain is folded around an iron-containing group called heme. It is actually the iron that forms a loose association with oxygen.” (Mader 1993: 614)

grounded laws. If Fs refer to all and only structures like in (GL2) the grounded law is nearly safe from exceptions. *Nearly*, not *totally*, because the underlying laws could be laws with exceptions. But let us assume we have strict underlying laws then, because of the supervenience relations defined, the grounded law is strict. Every non-G event is a non-F event such that no exception is possible. This is why grounded laws can indeed get very close in character to those fundamental laws we intuitively think of when we think of the prototypes of lawhood. When Fs are realised by (GL2) structures the grounded law even inherits necessity from its pedigree laws (if we believe in nomological necessity). For the same reason grounded laws also support counterfactuals.

Answer 2 is an argument from scientific practice: chemistry, biology etc. are full of regularities as described in grounded laws (cf. haemoglobin). Grounded laws are the relevant law candidates for those sciences.

Answer 3 is a negative answer: grounded laws aren't laws. Only the fundamental laws are laws. If this is so, the answer to my core question whether there are real *ceteris paribus* laws at all (in the metaphysical reading) depends on the fundamental laws (non-grounded laws) alone.

By the way, that the so called *fundamental* laws of physics are non-grounded does not mean *per se*—in my definition—that they ground the laws of, say, chemistry. However, the notion of a *fundamental law* can be analysed in terms of groundedness and non-groundedness. Thereby a double meaning of *fundamental* is revealed: a law *L* is *fundamental* iff it is *non-grounded* and *grounding*. However, it is very hard to think of a non-grounded law that is not grounding any grounded law (but just exists for itself). This is probably why the double meaning of 'fundamental' has not yet been revealed.¹⁶

(ii) What if most Fs are realised by (GL3) structures which do not secure the occurrence of Gs? Is it then still justified to call the grounded law a law? There is, indeed, no statistical normalcy claim in my definition of grounded laws and a grounded law with only negative instances has little predictive and explanatory value. Remember, however, that I aim to give a pure metaphysical description of what could possibly be a law with real exceptions. That those laws (or many of them) are useless for epistemic subjects is not a welcome feature for us but, on the other hand, not a conclusive argument against them. Epistemic subjects will be keen on those grounded laws which are relatively often and relatively stably realised by (GL2) structures. But the grouping into good and bad laws is just superimposed on the total class of grounded laws and does not endanger the metaphysical core.

More, however, can be said about the character of the epistemically advantageous grounded laws. I think that those laws involve natural kinds. If we go with Putnam and Kripke natural kinds have certain properties essentially. Amongst those properties are structural properties which figure in underlying laws. In short, if Fs, in grounded laws, are complex objects including natural kinds as parts then Fs will have some (GL2)-like structures essentially and hence the strict success of the grounded law is guaranteed. If,

¹⁶ This is also the reason for which I allow myself to use *fundamental* and *non-grounded* synonymously when no confusion can result.

on top of that, we can argue plausibly that it is not us dividing nature into parts as it suits us but that we carve nature at its joints such that natural kinds are a genuine metaphysical category (and not human made epistemic entities) then we have even established a sorting mechanism on the class of grounded laws which is based on metaphysics: the good ones involve natural kinds, the bad ones do not.¹⁷

(iii) But worse is to come. In (GL3) I have demanded “if there is a total match for all P_i, P_j^* between $\langle C_1, \dots, C_{n(x1)} \rangle$ and some permutation of $\langle C_1', \dots, C_{n(x2)} \rangle$ then $Fx_1 \equiv Fx_2$ and $Gx_1 \equiv Gx_2$ and yet $\neg \forall x (Fx \supset Gx)$ (which is not to say that $\neg \exists x (Fx \wedge Gx)$)”. But what if, with the help of the P_i^* properties and the (grounding) laws amongst them, it is actually the case that for (GL3) realised Fs that $\forall x (Fx \supset \neg Gx)$? Then we can swap the roles of the P_j s and the P_j^* s and get the second grounded law *Fs are non-Gs*. Hence, both *Fs are Gs* and *Fs are non-Gs* would come out as grounded laws. As *ceteris paribus* laws, to be sure, but as laws.

We could cure this disease of grounded laws by changing “... and yet $\neg \forall x (Fx \supset Gx)$ (which is not to say that $\neg \exists x (Fx \wedge Gx)$)” to “ $\exists x (Fx \wedge Gx)$ and $\exists x (Fx \wedge \neg Gx)$ ” such that the P_j^* properties neither secure $\forall x (Fx \supset Gx)$ nor $\forall x (Fx \supset \neg Gx)$. But that is unrealistic for the following reason. A real exception to a grounded law is not a miraculous event which just so happens. An exception has a cause which is well grounded in the fundamental laws the world is governed by. Hence, we have another bullet to bite if we want to defend grounded laws: unless Fs refer exclusively to (GL2) structures there is the possibility that next to every grounded law *Fs are Gs* there is also the opposite one: *Fs are non-Gs*. But that surely contradicts our intuitions about lawhood.¹⁸ Again, it is only positively high statistics of F realisations in favour of G which could somehow rescue the initial law to be a law.¹⁹

9. Grounded Laws: Evaluation

But, in the end, how much damage can all this do to an inquiry whether there could be laws with exceptions? Not too much I hope. Even if the concept of a grounded law has

¹⁷ Lewis writes on that issue: “Fundamental laws, those that the ideal system takes as axiomatic, must concern perfectly natural properties. Derived laws that follow fairly straightforwardly also will tend to concern fairly natural properties. Regularities concerning unnatural properties may indeed be strictly implied, and should count as derived laws if so.” (Lewis 1999: 42)

¹⁸ I was pleased to see that Schurz comes to a similar conclusion about *ceteris paribus* laws while arguing in a completely different way to mine: cf. (Schurz 2001: 367)

¹⁹ A final note on this matter: in the same way a crude property nominalism could suffer from an implausible abundance of properties my account of grounded laws could lead to an overpopulation of laws: take any event you like and baptise it with the kind name F. Everything else *like that* shall qualify as F as well (this is meant to be a Putnam / Kripke style paradigm case baptising, a reference to an archetypal F). Wait a second and see what happens next. Call the next event G (and everything else *like it*: again Putnam / Kripke at work). Additionally presuppose a minimal determinism. Voilà, a grounded law: $\forall x (Fx \supset Gx)$. (And maybe even a strict one depending on how narrow or fine grained Fs and Gs are defined by this paradigm reference fixing business.)

also a strong epistemic character to it—because it is likely that it is us choosing the concepts figuring in the law statements of grounded laws—the exceptions a grounded law can have can still be of the real character I was looking for: the grounded law’s effect might be missing not only because it is masked or diluted for epistemic subjects but because it is just not there. And this is how I defined a proper metaphysical exception.

The two extreme cases are thus: (i) we do not accept grounded laws as laws at all. They have rather the character of handy rules. And yet, the exception to such a rule would be a genuine exception. (ii) We do count them as laws, although the concept of a grounded law is very much impregnated with questions of how to map higher level concepts to lower level concepts as highlighted above. In that case we have a very good candidate for laws with real, metaphysical exceptions.

My final answer is, hence, conditional: if grounded laws qualify as laws at all they are good candidates for being real *ceteris paribus* laws in the metaphysical reading; if they do not the question is handed over to non-grounded laws.

10. Non-Grounded Laws: an Outline

There is no space left for a full analysis of our concepts of fundamental or non-grounded laws in order to answer the question whether exceptions to those laws can be allowed. I think they can but here I can only present a very sketchy argument for my belief. I will first give a general, metaphorical argument why I think that a concept of exception ridden fundamental laws are possible. Afterwards, I outline how that idea can be incorporated into one of the orthodox theories of lawhood, namely the Ramsey-Lewis view.²⁰

One of the initial ideas to distinguish laws from accidents was to claim that law statements—as opposed to sentences that state pure accidents—are true universal statements whose predicates refer to scientifically kosher properties. This assumption did not succeed for of the two following syntactically and semantically alike statements (both contain only scientifically respectable predicates and both are universal quantifications) the first is a good candidate for a law, the second is not:

1. All solid spheres of enriched uranium (U235) have a diameter of less than one mile.
2. All solid spheres of gold (Au) have a diameter of less than one mile.

Philosophers have concluded that in order to distinguish laws from accidental generalisations a law must be a generalisation plus some X. Many Xs have been suggested: by

²⁰ In short: Laws are “consequences of those propositions which we should take as axioms if we knew everything and organized it as simply as possible in a deductive system. [...] A contingent generalization is a *law of nature* if and only if it appears as a theorem (or axiom) in each of the true deductive systems that achieves a best combination of simplicity and strength. A generalisation is a law at a world *i*, likewise, if and only if it appears as a theorem in each of the best deductive systems true at *i*.” (Lewis 1973: 73)

anti-Humeans, for example, *natural necessity* which is a relation between the universals the generalisation's scientific predicates refer to,²¹ or, by Humeans, the *membership in the best deductive system* which describes the world's history in the simplest and also strongest way.²²

My general idea for the possibility of fundamental laws with exceptions is now this: if we happen to live in a suitably messy world, then already *approximate generalisations* plus X are sufficient for lawhood. The hope is that we have overpaid the bill with the X additional to generality such that we can demand cash back which comes in the currency of exceptions. Of the two Xs from above the Humean's X (here: David Lewis' X), namely membership in the best deductive system, will turn out to be well suited for the task. Only a minor change to Lewis' theory makes his X so rich that it can pay for the exceptions. However, there is no space to give a detailed argument for this claim and I can only make it plausible by quoting a passage from Lewis:

A localized violation is not the most serious sort of difference of law. The violated deterministic law has presumably not been replaced by a contrary law. Indeed, a version of the violated law, complicated and weakened by a clause to permit the one exception, may still be simple and strong enough to survive as a law. (Lewis 1973: 75)

All depends on how extended the violation is: if it is temporally and spatially limited, i.e., “a small, localized, inconspicuous miracle” (Lewis 1973: 75) then it is easy to imagine that the loss of simplicity and strength (Lewis' X) we have to accept when we amend the antecedents of those laws still does not affect the robustly best position of the best system.

11. Summary

I have started this paper by pointing out that many people not only think that most laws are *ceteris paribus* laws but also that there are *ceteris paribus* laws all the way down to fundamental physics. Although this might be true proponents of *ceteris paribus* laws have drawn that conclusion on wrong assumptions. I have, hopefully, made plausible the idea that there are two different readings of law statements with *ceteris paribus* clauses: a metaphysical vs. an epistemic reading. Both cases have been mixed up and it is this confusion which led to the verdict that there are laws with exceptions even in fundamental realms. Once freed from epistemic considerations, it is, however, still a metaphysical question which seeks an answer whether we can have a concept of laws which allows them to have exceptions. Having turned to this metaphysical reading of the *ceteris paribus* issue entirely (and thereby having turned to the main question of my article), I have divided laws into two kinds—grounded laws vs. non-grounded laws. I have examined grounded laws in detail and I have drawn a conditional conclusion: if

²¹ Cf., for example, (Armstrong 1983) and (Armstrong 1997).

²² Cf., for example, (Lewis 1973).

grounded laws qualify at all as laws they are candidates for laws with real exceptions. Exceptions to fundamental laws are also possible: at the end of this paper I have briefly outlined how we could formulate a concept of fundamental laws of nature which allows them to tolerate at least small, localized, and inconspicuous violations. Whether there are such laws remains, however, an empirical issue.

Bibliography

- Armstrong, D. 1997. *A World of States of Affairs*. Cambridge: CUP.
- Armstrong, D. 1983. *What is a Law of Nature*. Cambridge: CUP.
- Cartwright, N. 1983. *How the Laws of Nature Lie*. Oxford: OUP.
- Cartwright, N. 1989. *Nature's Capacities and their Measurement*. Oxford: OUP.
- Cartwright, N. 1995. "Précis of Nature's Capacities and Their Measurement", in: *Philosophy and Phenomenological Research* 55(1), 153–156.
- Cartwright, N. 1999. *The Dappled World. A Study of the Boundaries of Science*. Cambridge: CUP.
- Cartwright, N. 2002. "In Favor of Laws that Are Not *Ceteris paribus* After All", in: *Erkenntnis* 57(3), 425–439.
- Earman, J., Roberts, J. 1999. "*Ceteris paribus*, there is no Problem of Provisos", in: *Synthese* 118, 439–478.
- Hempel, C.G. 1988. "Provisos: A Problem Concerning the Inferential Function of Scientific Theories", in: *Erkenntnis* 28, 147–64.
- Lewis, D. 1973. *Counterfactuals*. Oxford: OUP.
- Lewis, D. 1986. *Philosophical Papers Vol. II*. Oxford: OUP.
- Lewis, D. 1983. "New Work for a Theory of Universals", in: *Australian Journal of Philosophy* 61, 343–377. (Here quoted from D. Lewis. 1999. *Papers in Metaphysics and Epistemology*. Cambridge: CUP.)
- Mader, S. S. 1993 (Fourth Edition). *Biology*. Dubuque, Melbourne, Oxford: Wm. C. Brown Publishers.
- Pietroski, P., Rey, G. 1995. "When other Things aren't equal: Saving *Ceteris paribus* Laws from Vacuity", in: *British Journal of Philosophy* 46, 81–110.
- Poincaré, H. 1958. *The Value of Science*. New York: Dover Publications.
- Schrenk, M. (forthcoming). "Les capacités peuvent-elles nous tirer des lois *ceteris paribus*?", forthcoming in: Kistler, M. and Bruno Gnassounou, B. (eds.): *Causes et dispositions. Actualité de la question philosophique de la causalité*, Paris: Presses Universitaires de France.
- Schurz, G. 2001. "Pietroski and Rey on *Ceteris paribus* Laws", in: *British Journal for Philosophy of Science* 52, 359–370.
- Stryer, Lubert. 1988 (Third Edition). *Biochemistry*. New York: W.H. Freeman and Company.