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# Dispositions in Physics[1]

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## 1. Introduction

According to a well-known story, physics no longer appeals to dispositional properties since early modern times. Descartes, for instance, writes in a letter to Morin (13.7.1638):

> Compare my assumptions with the assumptions of others. Compare all their *real qualities*, their *substantial forms*, their *elements* and countless other such things with my single assumption that all bodies are composed of parts. [...]. Compare the deductions I have made from my assumption – about vision, salt, winds, clouds, snow, thunder, the rainbow, and so on – with what the others have derived from their assumptions on the same topics.[2]

Real qualities and substantial forms were conceived of as dispositional properties. Descartes rejected them because he took them to be explanatorily useless.

And indeed Descartes was not the only one to reject dispositions.[3] The point, however, is that *a certain kind* of disposition was rejected – dispositions as causal powers. In what follows, I will argue there is a different sense of dispositions that is presupposed in physical practice: Dispositions as contributors. What I will claim is that dispositions as *contributors* are presupposed in physics precisely because of the competing explanatory strategy that Descartes mentions: explaining the behavior of bodies in terms of the parts.

I will argue firstly that law-statements should be understood as attributing dispositional properties. Second, the dispositions I am talking about should not be conceived as causes of their manifestations but rather as contributors to the behavior of compound systems. And finally I will defend the claim that dispositional properties cannot be reduced in any straightforward sense to

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1 I would like to thank Rosemarie Rheinwald and the participants at the Wittenberg conference on dispositions for helpful comments on earlier versions of the paper.

2 Descartes 1991, 107 (AT II, 200).

3 Newton, for instance, writes: "...since the moderns – rejecting substantial forms and occult qualities – have undertaken to reduce the phenomena of nature to mathematical laws ..." (Newton 1999, 381).

non-dispositional (categorical) properties and that they need no categorical bases in the first place.

## 2. Laws attribute Dispositional Behavior to Physical Systems

Let me start by giving some examples of the attribution of dispositional properties in physics. Newton in the third part of his *Principia* argues that certain well-known phenomena – among them Kepler's laws – can be deduced from his theory. Proposition 13 of Book III of the *Principia* captures Kepler's first and second law:

> The planets move in ellipses that have a focus in the center of the sun, and by radii drawn to that center they describe areas proportional to the times. (Newton 1999, 817)

Newton argues for this theorem as follows:

> Now that the principles of motions have been found, we deduce the celestial motions from these principles a priori. Since the weights of the planets toward the sun are inversely as the squares of the distances from the centers of the sun, it follows (from book 1, props, 1 and 11, and prop. 13, corol. 13) that *if the sun were at rest and the remaining planets did not act upon one another, their orbits would be elliptical having the sun in their common focus, and they would describe areas proportional to the times.* (italics mine) (Newton 1999, 817/8).

The point is that the behavior that Newton attributes to the planetary system and that he deduces from his principles is not one that the planetary system in fact displays. It would display or manifest the behavior if there were no external influences. As a matter of fact, Newton argues, these influences are small and thus we get something very close to what Kepler attributed to the planets. For our purposes, however, it is not important whether or not the external influences are small. The important point is that certain behavior is attributed to the planetary system provided certain circumstances obtain, which as a matter of fact fail to obtain. The behavior that Newton attributes to the planetary system is not manifest. It would be manifest if the influences were absent.

Newton's first law is another and a much simpler example for the attribution of conditional behavior:

> Every body continues in its state of rest or of uniform motion in a straight line, unless it is compelled to change that state by forces impressed upon it. (Newton 1999 416)

Again, the law attributes behavior to bodies. It says that the bodies would manifest certain behavior in the absence of disturbing factors or forces. On the view that laws should be read as attributing properties to systems, the laws we have just discussed attribute a property to bodies that becomes manifest given the right circumstances. In other words, Newton's first law attributes a dispositional property to the body. The bodies *have* the property whether or not the forces are present. The property becomes manifest if the forces are absent.

This observation on Newton's first law seems to be true of most laws in physics. They attribute behavior to physical systems provided there are no external influences, no disturbing factors. Take the following example:

> Hydrogen atoms behave in accordance with the Schrödinger equation with a Coulomb potential.

This law is true provided there are no external electric or magnetic fields. Thus it attributes a behavior to hydrogen atoms that becomes manifest only given certain conditions are fulfilled. That is, the law statement attributes a dispositional property to the atoms.

I employ the categorical/dispositional distinction as follows: A dispositional property is a property that, if instantiated by an object, is manifest under specific conditions only. A categorical property by contrast is a property that, if instantiated by an object, is manifest under all conditions. So, according to this distinction categorical properties are limiting cases of dispositional properties.

Two remarks: First, there is of course the problem of exactly specifying under which conditions a particular disposition becomes manifest. The way I draw the distinction does not imply that this can be finitely done. Second, in the limiting case of a categorical property the distinction between a property and its manifestation doesn't do any work.

This is certainly not the orthodox way to draw the distinction, but the usual suspects fall on the right sides. Solubility and fragility, if instantiated by an object, become manifest under specific conditions. On the other hand, triangularity or massiveness, if instantiated by an object, are manifest under all conditions.

Given this distinction we can sum up what has been said about laws as follows: The behavior that laws of nature typically attribute to physical systems is a behavior that becomes manifest given certain circumstances obtain – usually the absence of external disturbances. Law statements thus attribute dispositions to physical systems.

## 3. Missing Instances – a Problem for the Categorical View

Let me now illustrate how the assumption of dispositional properties solves some problems that arise on the competing view that laws attribute categorical properties to physical systems. Here is the problem: If laws attribute categorical properties to physical systems, they attribute properties that, if instantiated – i.e. if the system in question has the property –, are manifest under all conditions. *A fortiori*, according to this view, if a categorical property is not manifest, it is not instantiated – the system does not have the property.

But clearly, the behavior that our above law statements describe is hardly ever – if at all – manifest. Thus the laws that I have cited above seem to have no instances. There seem to be no systems that display the behavior in question. There simply are no bodies that are *not* compelled to change their state due to forces impressed on them. So Newton's first law is never instantiated (with the possible exception of the universe as a whole). What then is the point of affirming rather than denying Newton's first law? Similarly, there simply are no hydrogen-atoms that live in field-free surroundings, so what is the point of the claim that hydrogen atoms behave according to the Schrödinger equation with the coulomb-potential?

In fact we have three problems here: Laws often appear to have no instances. Thus:

- How can laws that attribute properties to physical systems, which appear to have no instances, be tested?
- How can laws that attribute properties to physical systems, which appear to have no instances, be explanatorily relevant for actual phenomena?
- Why are we *interested* in laws that attribute properties to physical systems, which appear to have no instances? What's the point of postulating these laws that describe what is going to happen when there are no forces – even though we know that these are always present? (Cartwright 1989, 189)

## 4. Testing Laws that appear to have no Instances

I will start by having a look at how laws that attribute properties to physical systems, which appear to have no instances, can be tested. An analysis of what goes on in testing will provide answers for the other questions as well.

Let me start with an example. According to Galileo, all bodies fall with the same speed in a vacuum. This is how Salviati, Galileo's spokesman, argued for this claim:

> We have already seen that the difference of speed between bodies of different specific gravities is most marked in those media which are the most resistant: thus, in a medium of quicksilver, gold not merely sinks more rapidly than lead but it is the only substance that will descend at all; all other metals and stones rise to the surface and float. On the other hand the variation of speed in air between balls of gold, lead, copper, porphyry, and other heavy materials is so slight that in a fall of 100 cubits a ball of gold would surely not outstrip one of copper by as much as four fingers. Having

> observed this I came to the conclusion that in a medium totally devoid of resistance all bodies would fall with the same speed.[4]

What is the law that has been tested? It is certainly not the law that all bodies fall with the same speed. That would be false. A tomato and a table tennis ball, when released from the top of staircase, reach the ground floor in different times. The law that has been tested is not a law about falling bodies in a medium. Rather the law in question pertains to the vacuum. All bodies fall with the same speed in a vacuum. The law concerns situations in which no disturbing factor, such as a resisting medium, intervenes. The role of the experimental results concerning falling bodies in the media is to provide *evidence* for the law in the vacuum. Salviati is not interested in the fact or the regularity that gold sinks in quicksilver as such. But rather because it provides evidence (in the context of the other results) for what would happen in the vacuum.

On the view that law-statement describe categorical properties this procedure generates a puzzle. In the actual experimental situation the alleged categorical property is not manifest and therefore not instantiated. How can Salviati gain evidence for a counterfactual situation in which the categorical property would be manifest, but which is, after all, *counter*factual?

I will now try to explain how on the dispositionalist view this puzzle disappears. The remarkable thing is that the law concerns a situation (vacuum) that is not realized and maybe even non-realizable. However, I assume that nobody will deny that it can nevertheless be tested along the lines Salviati has outlined. So how does it work?

The following explanation of the test procedure seems reasonable: The first point is that, if Saliviati's argument is to work, the ideal (the counterfactual) and the less than ideal (the real) situation must be connected. The ideal situation is the situation in which no disturbing factors are present, i.e., the situation in which the manifestation conditions obtain. The relevant systems, i.e., the falling body in the medium and the falling body in the vacuum, must have something in common. It is plausible to assume that there is something that is present in the less than ideal situation and would be present in the ideal situation. Salviati's argument works because the system, the falling object, has some kind of feature, some kind of property, which is present in the less than ideal situation and would also be present if the ideal were realised.

But, secondly, it clearly cannot be a categorical property. A categorical property is a property that is manifest whenever the system has the property. The behavior that Salviati attributes to the falling bodies (falling with a certain velocity) cannot be considered to be such a property because it is manifest in the vacuum only. The property is not always manifest. What we have is:

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4 Galilei 1954, 71-2.

Something carries over from the ideal to the less than ideal.[5] It would be present and manifest under ideal circumstances. It is present but fails to be (completely) manifest in less than ideal circumstances. Properties of systems that become manifest under certain conditions only are dispositional properties as opposed to categorical properties that are manifest in all circumstances. Thus, given that the behavior of the falling body is a dispositional property, we understand how our knowledge of what is going on in the less than ideal situation carries over to the ideal situation. By contrast, Salviati's argument would generate a puzzle, if law statements were understood as attributing categorical properties to physical systems.

Thirdly, even though the falling bodies do have dispositions that are not (completely) manifest in the less than ideal situations these situations provide evidence for the ideal situations. That couldn't be the case if manifestation were an all or nothing affair. The point is that the disposition is *partially manifest* in the less than ideal situation and this provides the basis for an extrapolation to the ideal situation.

In this context it is helpful to introduce a distinction I have drawn elsewhere: Fragility is an example of a discontinuously manifestable disposition (DMD). A thing is either broken or it is not; fragility cannot be partially manifest. It is an all or nothing affair.[6] Not all dispositions are *dis*continuously manifest. Continuously manifest dispositions (CMDs) allow for partial manifestations. If the partial manifestations are continuously ordered they allow for extrapolation.

Take, for example, properties that we attribute to ideal crystals: conductivity, specific heat, etc. There are laws that attribute behavior to the crystal in case there are no impurities (disturbing factors). Even though what the laws attribute are dispositional properties, which – presumably – will never be completely manifest, we can nevertheless get empirical evidence for the disposition's obtaining.

We can order different samples of the crystal according to the degree to which the manifestation condition is realized. The fewer the impurities, the more the manifestation condition is realized. If we measure the quantities in question with respect to the different samples, we are able to extrapolate to the behavior of the pure system as the limiting case. The disposition is partially manifest in the non-ideal situation. The transition from the less than ideal to the ideal is continuous so as to allow for extrapolation.

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5 This is essentially Cartwright's argument for capacities (Cartwright 1989, 189).

6 Apparently intuitions are divided on whether a thing can be partially broken or not. Anyway, for the purposes of this paper I am not committed to the view that there are examples for DMDs. All I am claiming is that the dispositions that law-statements ascribe to physical systems are CMDs.

The falling objects in a vacuum as discussed by Salviati provide another example of a CMD. The thinner the medium, the closer we approach the ideal condition, the more the behavior in question becomes manifest. Given such continuity we can accumulate evidence for what would happen if the ideal circumstances were realized even if they actually never are. The partial manifestations of the disposition allows for an extrapolation to the ideal situation under the assumption of continuity between partial and complete manifestation.

I have used such notions as 'partial manifestation' and 'continuity'. *Prima facie* these appear to be rather vague concepts. But as a matter of fact they can be made precise in physics. The central idea is this: A system in a less than ideal situation, i.e. in the presence of disturbing forces or other influences, is part of a compound system. The behavior of such a compound system can be explained in terms of what the parts contribute to the compound behavior. Thus, the system's behavior is partially manifest if the system *contributes* to the behavior of the compound system of which it is a part and of which the disturbing factors are parts as well. These contributions can be made quantitatively precise.

Let me illustrate this through a simple example. Take a compound massive system consisting of three subsystems. We are only interested in mass. Leaving out relativistic effects we know that the mass of the compound (M) adds up as follows:

$$m_1 + m_2 + m_3 = M.$$

Thus, what we have is a law of composition for our three masses. There are similar laws of composition for vectors (such as velocities and forces) or tensors. The law tells us how the different subsystems contribute to the mass (behavior) of the compound. It also tells us what would happen in the limiting case of, say, $m_1$, approaching zero.[7]

In the case Salviati describes, we can consider the medium plus the falling body as a compound system and provide – at least in principle – a complete account of its behavior. There are laws of composition that tell us how the different contributions such as the disturbing factors affect the behavior of the compound system. Thus, a system in the presence of disturbing factors can be conceived of as a compound consisting of the system in question plus the other factors. The laws of composition will also tell us what is going to happen if the medium (a disturbing factor) is replaced by a thinner medium. So it is furthermore possible to make precise the notion of continuity between the less than ideal and the ideal.

7 More on laws of composition in Hüttemann 2004, chapter 3.

So, if we have a complete description of all the contributing factors, it is the laws of composition on the basis of which we can give a quantitative account of *partial manifestation* and of *continuity* between the non-ideal and the ideal situation.

## 5. Solutions

Those problems that are generated on the view that laws attribute categorical properties to physical systems are absent on the rival view that they attribute dispositional properties:

- How can laws that attribute properties to physical systems, which appear to have no instances, be tested?

The problem disappears if it is assumed that law statements attribute continually manifestable dispositional properties to physical systems. The properties in question are instantiated in the less than ideal situations though not (completely) manifest. But partial manifestation suffices for extrapolation and therefore for testing laws that are not manifest.

They can be tested because their partial manifestation provides the basis for an extrapolation to what would happen in the ideal situation – to what would happen if the manifestation conditions were realized.

- How can laws that attribute properties to physical systems, which appear to have no instances, be explanatorily relevant for actual phenomena?

Even though the dispositional properties are not completely manifest, they are instantiated, i.e. the system has the dispositional property in question and in this sense the property is actual. So we explain something actual in terms of something that is actual. They are explanatorily relevant for actual phenomena because we can explain actual phenomena in terms of contributions of various factors (all of which are partially manifest dispositional properties which are instantiated by the systems in question).

- Why are we interested in laws that attribute properties to physical systems, which appear to have no instances? What's the point of postulating these laws that describe what is going to happen when there are no forces – even though we know that these are always present?

We are interested in laws that attribute dispositional behavior to physical systems because that allows us to explain the behavior of compound systems in terms of contributions. It enables us to explain the behavior of compound systems in terms of the behavior of the parts.

## 6. Rejoinder by the Categoricist

I argued that understanding law-statements as ascriptions of dispositional properties of a certain kind makes rational how we test laws and how we explain the behavior of compound systems in terms of contributions of the parts (micro-explanation). But maybe the categoricist has an explanation as well.

According to the categoricist (or the 'humean' metaphysician) Salviati is merely confronted with certain laws that can be understood as attributing categorical properties to physical systems. One law concerning gold in quicksilver, another one concerning wood in quicksilver, one law concerning gold in air and another one concerning wood in air. These various regularities can be understood as attributing behavior to certain compound systems such as gold in quicksilver or wood in the air. The behavior in question is manifest (gold actually falls with a determinate velocity and acceleration in quicksilver). We do not have to appeal to non-manifest dispositional behavior. The Humean or categoricist can provide a consistent description of all that happens.

In reply it has to be admitted that the categoricist can indeed provide a consistent and complete account of all that happens (of all events). The question, however, is: What do we expect of a metaphysical theory? Its job is not just to give a complete and consistent description of events. Even a naïve regularity account of laws could achieve that. The problem with a naïve regularity view of laws of nature was not that it failed on this count. The problem was that it was unable to give an account of the role laws of nature play in scientific practice, such as in explanation, confirmation and induction.[8]

Similarly, I want to argue that the categoricist cannot explain the role of laws of nature in scientific practice. More particularly, two things need to be mentioned in this context:

- On the categoricist's view it remains unclear why the cases that Salviati mentions have anything in common. What is it that connects the different laws? Why can Salviati legitimately infer from the observed phenomena to the ideal case?
- The law that Salviati is interested in and is testing concerns falling bodies in a vacuum, not in a medium. Similarly we are very often interested in

8 Armstrong 1983, 39-59.

> ideal crystals etc. (Thus we try to shield off external influences in experiments.) On the categoricist's view it remains unclear why we are interested in these ideal cases.

These problems stay with the categoricist even if higher order laws are introduced.[9] These are meant to systematize the empirical laws I have mentioned. We can think of Newton's second law or the Schrödinger-equation as higher order laws that allow for lower-level laws with missing values. Thus Newton's second law tells us (given the right force-functions) how bodies gravitate towards one another and thus how bodies fall. Such higher order laws would allow for missing values. Newton's second law tells us what would happen, if certain forces, that are in fact not actual, were to obtain. It also tells us what would happen if no forces were present (the ideal case I mentioned).

Even if we assume that we introduced these higher order laws for reasons of simplicity and systematization, the problems of the categoricist remain. The account still does not explain why we are in particular interested in the ideal cases. Why is Salviati interested in the vacuum case rather than in the other cases? Why do ideal cases serve as a basis for explanations of compounds' behavior?

The categoricists or Humeans may be able to give a complete and consistent account of all that happens, however, they cannot give a rationale for the role laws of nature play in scientific practice.

## 7. The Explanatory Role of Dispositions

I will now turn to the explanatory role of dispositional properties that laws of nature ascribe to physical systems. Two aspects can be distinguished. First, there is the argument for dispositions that has just been outlined. The assumption that physical systems have CMDs is the best explanation for the success of part-whole-explanations (micro-explanations) and for extrapolations to ideal cases.

Second, we have to look at the role of dispositions within such explanations. In an explanation, in which we appeal to CMDs, the explanandum is usually *not* the manifestation of the dispositions in question. In fact, it is usually the case that these dispositions fail to be perfectly realized. Bodies usually fail to continue in their state of rest or of uniform motion in a straight line, because disturbing forces are present. In these cases the alleged explanandum, the manifestation does not even exist. But even if we would come across a case in which a body manifests the disposition that Newton's first law men-

9 Armstrong 1983, 111-116.

tions, we would not explain the fact that the body continues in its state in terms of the disposition. The fact that a body continues in its state of rest or of uniform motion in a straight line in the absence of disturbing factors is a brute fact and remains a brute fact, even with the assumption of an underlying dispositional property. So, I will argue for the claim that CMDs are *not* introduced as *causes* of their manifestations, but rather as *contributors* to the behavior of compound systems. (That makes CMDs different from Cartwright's capacities.)

In an explanation, in which we appeal to CMDs, the explanandum is usually the behavior of some compound system (the falling stone in the medium, the dissolved sugar in the water, the moving body in an external force field) and we appeal to the dispositional non-manifest behavior of the parts.

If we explain the behavior of a compound system in terms of parts we want to attribute certain properties to the parts in terms of which the behavior or property of the compound can be explained. We want to know what the different parts *contribute*. Thus, my claim is that in physics we appeal to dispositions as *contributors* to the behavior of compounds – not as causes.

But aren't the dispositions causally relevant for the manifestations of the compound's behavior? Clearly the dispositions are relevant for the compound's behavior, but they are not *causally* relevant. The masses of the parts *contribute* to the mass of the compound – they don't *cause* the compound to have a certain mass.

According to the physical part-whole relation the behavior of the parts and the laws of composition determine the behavior of the compound. The compound's behavior is thus counterfactually dependent on the behavior of the parts. This, however, does not imply that the relation is causal. If one assumes that causal relations are temporal, there is an easy way to see this. The part-whole relation is a synchronic relation, not a temporal relation. Therefore, the part-whole relation and thus the relation of the dispositions of the parts to the behavior of the compound cannot be a causal relation. It is due to the part-whole relation that we have to introduce dispositions in physics. The part-whole relation in physics is a non-causal relation. Therefore, dispositions in physics should not be considered as causes of their manifestations.[10]

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10 In Hüttemann 2004, 83ff. I argue in more detail why the part whole relation is non-causal.

## 8. The Irreducibility of Dispositional Properties to Categorical Properties

In this final section, I will turn to the third claim I advertised at the outset. Dispositional properties cannot be reduced in any straightforward sense to non-dispositional properties.

For a start, let me recapitulate the distinction between dispositional and categorical properties: A dispositional property is a property that, if instantiated by an object, is manifest under specific conditions only. A categorical property by contrast is a property that, if instantiated by an object, is manifest under all conditions.

What would a reduction of dispositional property look like? Armstrong argues as follows:

> A good model for the identity of brittleness with a certain microstructure of a brittle thing is the identity of genes with (sections of) DNA-molecules. Genes are, by definitions those entities, which play the primary causal role in the transmission and reproduction of hereditary characteristics. [...] in fact sections of DNA play that role. So genes are (identical with) sections of DNA. (Armstrong 1996, 39)

This model of reduction is standard in the philosophy of mind and often called the functional model of reduction. It can easily be transferred to the case of dispositional and categorical properties.

Slightly modifying Stephen Mumford's terminology we have the following argument:

> The argument from the identity of functional role:
> 1. Disposition D = the occupant of role R.
> 2. Categorical Base C = the occupant of role R.
>
> Therefore: Disposition D = categorical base C. (Mumford 1998, 146)

Let us, for instance, assume that fragility can be functionally characterized as the property in virtue of which an object breaks, when suitably dropped. As it turns out the microstructure of the object is responsible for the breaking of the object if it had been suitably dropped. So fragility is identical with some micro-based property of the object in question. It turns out that even though we have two predicates, namely fragility on the one hand and the micro-description on the other, there is only one property that both refer to.

I think an argument of this kind is a good argument for the identification of fragility or solubility with some kind of micro-based property. In this sense I have no objection to the reductionist claim.

It is important to realize that this reductionist claim does not imply that the micro-structural property in question is *categorical.* Such a claim would require an additional argument. In fact it is hard to see how the micro-based property in question could be categorical. If it were a categorical property there would not have been a reduction in the first place. Fragility's functional role is the role of a dispositional property: to break if suitably dropped, i.e. to break given the appropriate circumstances. If the micro-based property realizes *this* role, then it is in virtue of the micro-based property that the object breaks, given *the very same circumstances.* If the property to be reduced is one that manifests a certain behavior under specific conditions then the reducing property, i.e. the one that is the occupant of the reducing properties functional role, must manifest the behavior in question *under the very same circumstances.* The micro-based property can be an occupant of the disposition's functional role only if it a dispositional property itself. For the reduction to work it has to be a reduction of a dispositional property to a dispositional property.

It might be objected that what Armstrong and others have in mind is reduction to categorical properties plus laws.[11] But as we have seen, an appeal to laws is an appeal to dispositions. So this move is of no help for the categoricist.

Second Objection: Couldn't the defender of reduction to categorical properties argue that in such a reduction appeal is typically made to mass, shape etc, i.e., to categorical properties. I agree that in such reductions one might appeal to properties such as the shape or the mass of a subsystem, which are probably the best candidates for categorical properties. But shape or mass on its own do not explain why a fragile glass breaks when suitably dropped. It is in virtue of the fact that the shape and mass (of the constituents of the fragile body) feature in laws that they are appealed to in the reduction of fragility and solubility. It is in virtue of the laws that we understand why the micro-property fills the relevant functional role. As I argued before, these laws are best understood as attributions of dispositions to physical systems. So the appeal to mass and shape does not undermine the claim that the reducing micro-structural property has to be a dispositional property.

The standard examples for dispositions in the relevant literature are solubility and fragility. It seems obvious that these need to be reduced to proper physical properties if there is a place for them in a physical description of the world. It is, however, important to separate two issues. One may very well agree that the above-mentioned dispositions stand in need of reduction *qua* being macro-properties that need to be connected to micro-physics. It is a separate issue whether properties need to be reduced to categorical properties because they are dispositional. If something is a macro-property of a compound system it might be reasonable to expect a micro-explanation (micro-reduction). As we have seen there is no reason to assume that dispositional properties as such should be reducible to categorical properties.

11 Armstrong 1996, 41.

There seems to be a widespread assumption that on a fundamental level there can only be categorical properties. But this is most likely not the case. Newton's first law:

> Every body continues in its state of rest or of uniform motion in a straight line, unless it is compelled to change that state by forces impressed upon it.

provides a perfect example of a law that attributes a dispositional property to physical systems. Nevertheless it cannot be reduced to anything more fundamental.

It has been argued that irreducible fundamental dispositions are incoherent. Simon Blackburn considers the case that science finds dispositional properties all the way down. The problem he sees is this:

> The problem is very clear if we use a possible world analysis of counterfactuals. To conceive of all truths about the world as dispositional, is to suppose that a world is entirely described by what is true at neighbouring worlds. (Blackburn 1990, 64)

On our conception of dispositions it would be wrong to claim that our world is described in terms of what is true in other worlds. Newton's first law, for example, is true of systems in our world because these systems have the relevant disposition in our world. Furthermore we have epistemic access to the non-manifest dispositions due to their partial manifestation. If the dispositions in question are continually manifestable dispositions the problem Blackburn envisages does not arise.

## 9. Conclusion

In this paper I have argued for the following claims: Contrary to what is often supposed, dispositions do play a significant role in understanding the scientific practice that has been established since the 17th century. I argued that given our interest in ideal cases, in what would happen if no disturbing factors were present, law-statements should be understood as attributing continually manifestable dispositional properties. Second, the dispositions I am talking about should not be conceived as causes of their manifestations but rather as contributors. And finally, I argued dispositional properties cannot be reduced in any straightforward sense to categorical properties.

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