



# Pandispositionalism and the metaphysics of powers

Samuel Kimpton-Nye<sup>1</sup> 

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## Abstract

Some philosophers maintain that physical properties are irreducibly modal: that properties are *powers*. Powers are then employed to provide explanations of other phenomena of philosophical interest such as laws of nature and modality. There is, however, a dispute among powers theorists about how far the powers ontology extends: are all manner of properties at all levels of fundamentality powers or are powers only to be found among the fundamental properties? This paper argues that the answer to this question depends on the details of the metaphysics of powers. More specifically, this paper argues that if one understands powers as qualitative grounds of dispositions (call this *qualitative dispositional essentialism*), as opposed to properties whose essences are constituted by dispositions (as orthodox dispositional essentialists would have it), then all properties, be they fundamental or *macro*, are powers, i.e., *pandispositionalism* is true. The Conclusion: If *qualitative dispositional essentialism* is true, then *pandispositionalism* is true, is significant because there is increasing concern that orthodox dispositional essentialism is explanatorily deficient and perhaps even incoherent, meaning that qualitative dispositional essentialism is gaining increasing support in the literature on powers. All things considered, then, it is beginning to look more likely that pandispositionalism is true *simpliciter*.

**Keywords** Explanation · Grounding · Laws of Nature · Modality · Pandispositionalism · Powers

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✉ Samuel Kimpton-Nye  
samuel.kimpton-nye@bristol.ac.uk; samuelknye@gmail.com

<sup>1</sup> The University of Bristol, Bristol, United Kingdom

## 1 Introduction

The idea that (at least some) properties are *powers* has gained a lot of interest and support in recent years. There is, however, a dispute about how far the powers ontology extends. Some authors admit powers at all levels of fundamentality, and in the service of all manner of philosophical explanations (see, e.g., Molnar (2003) Heil (2004), Mumford and Anjum (2011), Ellis (2013), Groff (2013)). Recently, however, Alexander Bird has argued that only fundamental properties (Bird, 2016), and some evolved non-fundamental properties (Bird, 2018), are powers and that the range of philosophical explanations that powers can provide is correspondingly limited. *Pandispositionalism*, the thesis that *all* properties are powers, is thus false, according to Bird, and he takes his arguments to significantly threaten the plausibility of the *macro powers thesis*, the thesis that the *many or all* macro properties are powers and that such properties play a role in explaining important phenomena involving macro entities (Bird, 2016, 342) (Bird uses ‘macro’ just as shorthand for non-fundamental, I will follow Bird in this respect).

Recently, the metaphysics of powers favoured by Bird<sup>1</sup> has come in for serious criticism (Barker and Smart 2012; Barker 2013; Jaag, 2014; Kimpton-Nye, 2021), which has motivated some to rethink the Birdian orthodoxy (Tugby, 2012, 2020, 2022a; Coates, 2020a, b; Kimpton-Nye, 2018, 2021); see also Ingthorsson (2013) and Yates (2013; 2018) for discussion of accounts of powers along similar lines though with slightly different motivations). What is interesting about this situation is that Bird’s arguments against the macro powers thesis and pandispositionalism depend upon the specific metaphysics of powers that he endorses, a metaphysics that, according to some, is seriously flawed. The point of this paper, then, is twofold. I will (in Sect. 4) show that the heterodox metaphysics of powers, call it *qualitative dispositional essentialism (QDE)*, defended by the aforementioned authors blocks Bird’s argument against the macro powers thesis and pandispositionalism; and (in Sects. 5 and 6) I will argue that in fact QDE implies that *all* properties are powers, i.e., that *pandispositionalism* is true.<sup>2</sup>

Before presenting the details of my arguments in Sects. 4, 5 and 6 I will (in Sect. 2) outline Bird’s specific metaphysics of powers and his arguments against macro powers. It is important to get clear on Bird’s metaphysics of powers because its details are integral to his arguments against the macro powers thesis and against pandispositionalism. In Sect. 3, I will present QDE and show how it contrasts with Birdian dispositional essentialism. It would be beyond the scope of this paper to provide an argument in favour of QDE. But the point of this paper is not to defend QDE (this task is taken up by Tugby (2012, 2020, 2022a, b); Coates, (2020b); Kimpton-Nye, (2018, 2021)) but is rather to argue that *if* QDE is the true account of the metaphysics of powers, *then* Bird’s argument against macro powers is unsound and, in fact,

<sup>1</sup> The same metaphysics of powers is endorsed by Chakravartty (2003; 2007) and by Mumford (2004), hence elsewhere (Kimpton-Nye, 2021) I have dubbed this the “canonical” dispositional essentialist view of powers.

<sup>2</sup> In a similar vein, Tugby (2022b) has recently argued that QDE is better positioned to resist “the conceivability objection” to pandispositionalism.

pandispositionalism is true. This is a significant conclusion because QDE is gaining increasing traction in the literature on powers and pandispositionalism is an interesting and controversial thesis.

## 2 Bird on macro powers

Bird thinks that there are some good arguments for the existence of powers but that these arguments only establish the existence of powers at the fundamental level, so we should be sceptical about claims to the effect that macro (i.e., non-fundamental) properties are powers. (Bird, 2018 also provides some arguments for high-level evolved powers, but these arguments are largely orthogonal to my concerns in this paper.) In this section, I first outline Bird's specific conception of powers and then his reasons for being sceptical about the claim that macro properties are powers.

### 2.1 Bird's conception of powers

Central to all accounts of powers is the notion of a *disposition*. A disposition, *D*, can be understood as a *modal relation* between stimulus, *S*, and manifestation, *M*, properties; *D* is the disposition to *M* when *S*. *Fragility*, for example, is a disposition to shatter when stressed, i.e., a modal relation between the properties *being stressed* and *shattering*. The dispositional relation is modal because an individual can be disposed to shatter when stressed even if it is never actually stressed and so never actually shatters (see, e.g., Tugby (2013); Coates (2020b, 2022)). Bird understands *powers* in terms of dispositions as follows:

A power is an ontic property that has a dispositional essence.

A power is an ontic property whose identity is given by its causal/dispositional/nomic role. (Bird 2007; 2016, 345; 2018, 249)

So, a power, according to Bird, is an ontic, as opposed to merely *predicatory*, property, whose *essence is constituted by* and, hence, whose *identity is given by*, dispositional relations between properties.

What is meant by the ontic/predicatory distinction? Bird (2018) follows Armstrong (1980) in maintaining that while almost any predicate picks out a property in the loose sense of 'property', we can also use 'property' more restrictively such that it has real ontological import. Thus, the ontic properties are genuine constituents of our ontology, plausible examples include *the property of being an electron*; *the property of having spin 1/2*, whereas the predicatory (or *abundant*) properties are not genuine constituents of our ontology, plausible examples include *being grue*; *being 1 mile from the Eiffel tower* (see, e.g., Bird 2018, 248). This leaves open the question of whether the ontic properties are drawn from all "levels" of reality, or just the fundamental level. On this, Bird seems to follow Schaffer's "scientific conception", according to which ontic properties are those invoked on our scientific understanding of the world and hence are drawn from all levels (Schaffer, 2004, 92). For the purpose of this paper, I will follow suit on both scores: ontic properties are to be understood

as real constituents of our ontology in contrast with merely predicatory properties and the ontic properties are those invoked in our scientific understanding of the world and hence can be found at all “levels” of reality. I’ll appeal to this account of ontic properties at various points in what follows.

From Bird’s claim that powers have their essences constituted by dispositions, it follows that “the very same power could not have a different dispositional character or causal role: that character or role is fixed across possible worlds” (Bird, 2016, 346).

*Modal fixity*: Powers are modally fixed properties (have invariant dispositional characters across possible worlds). (Bird, 2016, 346; 2018, 249)

## 2.2 Arguments for powers

Bird thinks that good arguments for powers focus on three areas—laws of nature, property identity and the metaphysics of modality—but that these arguments support only the claim that there exist *fundamental* powers.

Consider laws of nature. The dispositional nature of powers explains why there are regularities in the pattern of property instantiations throughout spacetime and hence explains the laws of nature (or, according to Mumford (2004), powers obviate the need for laws because they do all of the explanatory work for which laws are invoked). Furthermore, since the dispositional nature of powers is modally fixed, powers are able to account for the *necessity* of the laws of nature (Bird, 2016, 347; 2018, 250). (See, e.g., Bird (2007) for extensive discussion of the benefits that a powers-based account of laws has over its competitors).

The powers theory also provides an account of what it is to be a given property: “A property could not have a different set of dispositional relations with other properties. *P* and *Q* are the same property iff they have the same dispositional character” (Bird, 2016, 347). Bird thinks that this account of property identity is superior to that according to which properties are *quiddities*—where quiddities are primitively self-identical and different quiddities are merely numerically distinct from one another (see, e.g., Lewis (2009); Armstrong (1983)). Quidditism, but not the powers theory, allows for the generation of genuinely distinct (but qualitatively indistinguishable) possible worlds by swapping the dispositional/nomic roles of two (or more) properties. For example, the quidditist thinks that there is a genuinely distinct possible world in which charge plays the mass-role and mass plays the charge-role, whereas the powers theorist denies that there can be such distinctions without difference. This, in turn, means that quidditism, but not the powers theory, leads to scepticism about the occupants of dispositional/nomic roles (Bird, 2016, 347; 2018, 250) and, given the possibility that multiple quiddities occupy the same dispositional/nomic role, scepticism about whether or not our scientific terms genuinely refer (Bird, 2007, 73–79).

Finally, Bird is open to the idea that powers may account for possibility and necessity. Dispositions seem to be associated with possibility (either directly (Vetter, 2015) or via a link with counterfactuals (Borghini and Williams 2008; Jacobs 2010)); if there exists a disposition, *D*, with manifestation *M*, then it is *possible* that *M* obtains.

So, if powers are ontologically fundamental and their essences are constituted by dispositions, then powers may be able to ground facts about what is possible (see, e.g., Bird (2007, 218, fn. 143), Borghini and Williams (2008), Vetter (2015)).

### 2.3 Bird against macro powers

According to Bird, the above arguments count in favour of the claim that fundamental properties are powers but not the claim that macro properties are powers. This is because only fundamental powers are required to explain laws of nature and modality, and there are other options besides quidditism and the powers theory when it comes to accounting for the identity of macro properties. I'll briefly explain these points in turn.

Consider laws and modality first. Even assuming that the existence of fundamental powers is established by their ability to explain fundamental laws of nature and possibility, it does not follow that the existence of macro powers is similarly established by their ability to explain non-fundamental laws and possibilities for things with macro properties. This, according to Bird, is because the non-fundamental laws supervene on the fundamental laws. So, fundamental powers explaining fundamental laws *also* explains the non-fundamental laws; no further macro powers are required. Similarly, Bird claims that "what is possible or not regarding things with non-fundamental properties supervenes on what is possible or not regarding things with fundamental properties." (2018, 251). There are no possibilities left unaccounted for by the fundamental powers, so there is no need to invoke macro powers to explain modality.

Next consider property identity. Bird argues that while there may only be two options concerning the identity of fundamental properties: quidditism or the powers theory, this same dichotomy does not hold for macro properties. The identity of a macro property may also be given in terms of *composition*, or *structure*. As Bird puts it: "If one property is compounded out of other properties, then the identity of the property may be given by the nature of that composition." (2018, 251). So, just because quidditism is an unattractive account of property identity, it doesn't follow that macro properties must be powers because their identity may be given in some third way.

Bird also offers some direct counterexamples to pandispositionalism which purport to show that certain macro properties are not powers and hence that pandispositionalism is false. According to Bird, many properties in science "concern structure or composition, not disposition" or "concern the relationship of the entity to other things" (2016, 355). Examples include the following (Bird, 2016, 355):

*Chemical properties* such as aromaticity (the property of being a chemical compound that contains a benzene ring), being covalent (of a bond, in virtue of the electron distribution giving rise to the bond), and being a transition element (occupying a certain position in the periodic table).

*Biological properties* such as the property of being heterozygous at a particular locus (having different alleles at that locus), and being a dinosaur.

*Medical properties* such as being pericardial (the property of surrounding the heart).

Bird offers the above examples (and more) of properties in science that he claims are “not at all dispositional” (2016, 355–56)—the essences of the above properties are given not by dispositions but by composition, structure or (non-modal) relations to other entities.

Perhaps the pandispositionalist could respond that the above properties are nonetheless invariably associated with certain dispositions.<sup>3</sup> But even if there were some set of dispositions shared by all aromatic compounds, for example, Bird argues that, contra his definition of powers (see Sect. 2.1 above), these dispositions would not determine the essence, nature or identity of aromaticity because “what aromaticity *is* is a matter of the structure of the molecules and their bonds and electrons”. While this shared structure may *explain* the fact that aromatic compounds share some set of dispositions, any *necessary connection* between aromaticity and dispositions does not imply a relationship of essence (2016, 356) (cf. Fine, 1994).

There are other arguments for macro powers, which involve highlighting the work that macro powers can do in providing explanations of various phenomena of particular philosophical interest. For example, Mumford and Anjum (2011) argue that macro-level causal processes can be explained in terms of macro powers and so we should admit the existence of macro powers on the basis of the explanatory work that they can do. Bird objects that Mumford and Anjum’s arguments fail to establish the existence of macro powers because the account of causation in terms of powers fails, and even if it were successful, it wouldn’t depend on any feature distinctive of the *powers* ontology. But this argument, and other arguments for macro powers that Bird rejects for similar reasons, will not be of primary concern to me. Indeed, I share Bird’s scepticism about the extensive work to which powers have been put by the “*enthusiasts*”. The case in favour of macro properties being powers that I will present in this paper (Sect. 5) does not depend on there being any “powers-based accounts” of macro phenomena of particular philosophical interest. Having said that, pandispositionalism would, if true, have the benefit unifying, in one sense at least, the metaphysics of properties and hence of streamlining our ontology: instead of having two different *kinds* of property, powers and non-powers, there would only be powers.

Next, I will introduce an alternative account of the metaphysics of powers—*qualitative dispositional essentialism* (QDE). Then, in Sect. 4, I will show that QDE blocks Bird’s arguments against macro powers and in Sects. 5 and 6 I will argue that QDE implies pandispositionalism.

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<sup>3</sup> Mumford (2021) pursues this line with respect to *sphericity*, in response to Bird’s critique of macro powers. However, this misses Bird’s point: even if sphericity were necessarily connected with certain dispositions, this would not suffice for it to count as a power, according to Bird, because the essence and identity of sphericity is not given by its dispositions but by non-dispositional mathematical/structural features.

### 3 QDE

*Qualitative dispositional essentialism* (QDE)<sup>4</sup> has been offered as a way of overcoming certain influential problems for Bird's understanding of powers. For problems see Barker and Smart (2012), Barker (2013) and Jaag (2014), to which Tugby (2012, 2021, 2022a); Kimpton-Nye, (2018, 2021); Coates, (2020a, b) have offered QDE as a remedy. Unfortunately, it would be beyond my present scope to detail these problems and how QDE is supposed to remedy them, so this section will just be limited to a presentation of the core features of QDE.

According to QDE, the essences of powers are not exhausted by dispositions. In fact, the essences of powers are not constituted by dispositions at all. QDE understands powers as non-modal *in a sense*: the sense in which, for example, *aromaticity* is non-modal and *pericardiality* is non-modal: the essences of these properties can be specified independently of any dispositions or other modal notions. Powers, according to QDE, are thus self-individuating as opposed to being metaphysically individuated by their place in a structure of modal relations (this is the *qualitative* part of QDE).<sup>5</sup> But this is not to say that powers are *merely* numerically distinct from each other, rather, different powers have different “thick qualitative natures” (see Tugby (2020), Hildebrand (2016), Smith (2016)).

Central to QDE is the claim that powers, by their very (thick) natures (which you can call non-modal, in the previous sense, if you wish), *ground* dispositions (this is the *dispositional* aspect of powers). Furthermore, a given power, P, could not possibly fail to ground the disposition(s), D, that it does, because its particular qualitative nature is *essential* to it—a property instance would not be an instance of P if it did not have P's very nature (see Tugby 2012, 728)—and (we assume, with orthodoxy) grounding is necessitating, so if P grounds D it is necessary that D exists if P exists. QDE thus respects *Modal Fixity*. It is by grounding, and hence explaining, dispositions that powers are then able to explain laws of nature and perhaps even modality in general, according to advocates of QDE (for details see Kimpton-Nye 2018, 2021; Tugby, 2022a).

Actually, the point about Modal Fixity requires some qualification. There is debate in the literature on QDE about whether powers fully or merely partially ground their associated dispositions (Coates 2020a, 8357; Tugby 2021, Sect. 3; 2022b, 222). One might worry that if powers only partially ground dispositions, then Modal Fixity will fail because the dispositions, Ds, grounded by a given power, P, will vary from world to world depending on whether the other grounds for the Ds are present. However, this should not be seen as a serious threat to the spirit of Modal Fixity, which should primarily be understood as a rejection of the Humean principle of free modal recombination (see Tugby (2021, Sect. 5; 2022b, 222)). Even if (some) powers only

<sup>4</sup> Tugby (2012) coined the name (but in more recent work he calls it “the grounding view of powers” (Tugby, 2021, 2022a, b)); there is also some precedent for the view in Jacobs (2011) and Ingthorsson (2013).

<sup>5</sup> Some authors take “qualitative” just to mean something like *actual* or *real* (see, e.g., Giannotti (2019) and Taylor (2017; 2019) for recent discussion. This is not merely what I mean by “qualitative” here.



partially ground (some of) their associated dispositions,<sup>6</sup> this is consistent with the idea that the grounding connections nonetheless place constraints on the possible recombinations of properties and dispositions. This is still contrary to Humeanism, for example, which says that there are no constraints on which properties are associated with which dispositions in other possible worlds.

To see the point, assume that the powers P1 and P2 jointly ground the disposition D1, so P1 and P2 each partially grounds D1. Assuming also grounding necessitarianism (as is orthodox), it is still necessary that if P1 and P2 exist then D1 exists and is grounded in P1 and P2, hence there is no possible world in which P1 and P2 exist but D1 does not. So free recombination of properties and dispositions fails. Alternatively, we could say that P1 is necessarily connected with D1 *conditional* on P2 existing, which is something that the Humean denier of Modal Fixity would surely reject. What's more, the dispositions should not be understood as being *reduced* to anything non-dispositional (grounding is not reduction). So we have necessary connections between properties and (unreduced) dispositions in keeping with the anti-Humean spirit of Modal Fixity Tugby (2022b, 222) makes this point.

#### 4 Reassessing the case against macro powers

In this section, I argue that QDE renders Bird's *direct* argument against pandispositionalism, the argument from counterexamples, unsound (I note, however, that QDE does not affect Bird's *indirect* arguments, which work to undermine the motivation for macro powers). In Sect. 5, I argue with reference to the macro chemical property *aromaticity* that, given QDE, there are indeed some positive reasons for thinking that macro properties are powers. And in Sect. 6, I show how these considerations may be extended to argue that QDE implies pandispositionalism.

As discussed in Sect. 2.3, Bird's direct argument against pandispositionalism involves citing counterexamples: properties that play important explanatory roles in science by explaining certain dispositions of their bearers, and hence which are *ontic* (see Sect. 2.1), but whose essences can be specified without reference to any dispositions. Bird takes the properties in question to be non-powers because he thinks that for a property to be a power its essence must be *exhausted* by dispositional relations to other properties. According to QDE, however, it is no obstacle to a property being a power that its essence can be specified structurally, compositionally, or, more generally, independently of any dispositional relations to other properties, i.e., *qualitatively*. On this conception of powers, then, there is nothing to prevent the properties that Bird cites as "counterexamples" to pandispositionalism from being powers after all.

<sup>6</sup> It also seems likely that the answer to the question of whether powers fully or merely partially ground dispositions will vary from case to case; perhaps it is more plausible that *fundamental* powers will fully ground their dispositions, for example. And even if powers don't fully ground *all* of their associated dispositions, it is plausible that they will be full grounds for at least *some* such dispositions. Thanks to Matthew Tugby for discussion of this point.



In short: QDE renders Bird's direct argument against pandispositionalism *unsound* by falsifying its key premise about the metaphysics of powers. Bird's argument runs as follows:

1. If pandispositionalism is true, then all properties are powers (from the definition of "pandispositionalism").
  2. If a property's essence can be specified qualitatively, then that property is not a power (premise).
  3. *Aromaticity* is a property whose essence can be specified qualitatively (one example among many) (premise).
  4. *Aromaticity* is not a power (from 2 to 3).
- C. Pandispositionalism is false.

Premise 2 is false, given the QDE conception of powers, in which case Bird's argument by counterexample does not establish the falsity of pandispositionalism.

It is worth noting, however, that Bird's *indirect* arguments against macro powers (2016, Sects. 6–7) are unaffected by the above considerations. Bird's indirect arguments involve undermining the motivation for macro powers by showing that the philosophical work to which powers are put by the "enthusiasts" in accounting for, e.g., causation, intentionality and free will (among other phenomena) can be done just as well by *dispositions*—where dispositions carry no implication of *Modal Fixity*, which is at the core of the concept of a power. Disposition-based explanations of these phenomena depend only on such features of dispositions as their directionality and intensity. But the directionality and intensity of dispositions can be explained just as well by those who reject powers and Modal Fixity. Lewis and Armstrong would be in this latter camp. These authors would reject even the qualified sense of Modal Fixity discussed above (Sect. 3) because their commitment to modal combinatorialism implies a commitment to the free recombination of properties and the dispositions with which they are associated, something which cannot be maintained if properties even partially ground dispositions and if we assume, with orthodoxy, grounding necessitarianism.

The claim that properties are powers, where this carries an implication of Modal Fixity, is thus redundant in philosophical accounts of, e.g., causation, intentionality and free will (see Bird 2016, esp. Sections 6, 7, 8), so the accounts of these phenomena offered by the enthusiasts is no evidence for the existence of powers after all. Since it invokes the notion of grounding, the QDE conception of powers still maintains that Modal Fixity is central to powers, even if in a qualified sense according to which properties and dispositions are not *completely* modally free to recombine. Philosophical explanations in terms of macro dispositions that do not depend on Modal Fixity thus count no more in favour of macro powers on the QDE conception of powers than they do on the Birdian conception.

In the next two sections, I will argue that QDE implies that ontic macro properties are powers quite independently of whether or not these properties can be invoked in philosophical explanations of macro phenomena.

## 5 Motivating macro powers

I will now argue that if one endorses QDE, there are indeed positive reasons for believing that macro properties are powers. For the purpose of exploring this issue, I stick with the example of aromaticity, and argue that given QDE, aromaticity is in fact a power. Then, in Sect. 6, I show how, on the assumption that QDE is true, these considerations can be extended to mount a general defence of pandispositionalism.

Though Bird denies that aromaticity is a power (because it has a qualitative essence), he remains open to the following:

- i) aromaticity *explains* certain dispositions of its bearers.
- ii) aromaticity is necessarily connected with these dispositions.

For example, Bird says:

Even if we can light on a set of dispositions shared (**necessarily**) by all aromatic compounds, that complex of dispositions would neither be nor determine the nature, essence or identity of aromaticity. Rather, what aromaticity *is* is a matter of the structure of the molecules and their bonds and electrons. That in turn *explains* any shared dispositions. The **necessity** of any relationship between aromaticity and a disposition does not amount to a relationship of essence (or nature or identity). (2016, 356, bold emphasis added by me, though the italicisation is Bird's).

Bird also briefly discusses other properties whose essences concern constitution, or some (non-modal) relation to another entity, as opposed to disposition (being made of wood, being made of steel, being in the presence of oxygen), but which he nonetheless takes to *explain* dispositions such as flammability (2016, 357). What seems to be the case, then, is that Bird is happy to admit that qualitative properties, such as aromaticity, can explain dispositions and that they are necessarily connected with those dispositions. I will now argue that from the plausible assumption that aromaticity explains at least one disposition, and given general anti-Humean sympathies, it follows that aromaticity *grounds* that disposition and hence that aromaticity is a *power*, given the QDE conception of powers.

Explanations are generally thought to receive *support* from somewhere—typically *causal* relations, but the idea of non-causal explanation has become increasingly mainstream in recent years. The breaking of the window is explained by my throwing the stone and this explanation is supported by the causal relation between the stone throwing and the window breaking.

Now granting that aromaticity explains a disposition to produce aromatic ring currents<sup>7</sup> (for example), one may wonder what supports *this* explanation? Causation

<sup>7</sup>*Aromatic Ring Currents*: Delocalized  $\pi$  electrons in the aromatic ring are free to circulate. An electric current can thus be induced if a magnetic field is directed perpendicular to the plane of the aromatic system (as a result of Ampère's law). The ring current then generates a magnetic field inside the aromatic ring that is in the opposite direction to the external magnetic field that induces the current.

doesn't fit the bill here. Aromaticity doesn't cause a disposition to produce aromatic ring currents because the two properties vary synchronically with one another—the instant aromaticity is present, so is the disposition to produce aromatic ring currents—but causal relations are generally thought to be diachronic (see, e.g., Craver 2007; Kim, 2000; Mellor, 1995; Russell, 1912; for an opposing view see Friend 2019).

What seems more likely is that the relation between aromaticity and a disposition to produce aromatic ring currents is a grounding relation—aromaticity grounds a disposition to produce aromatic ring currents. (See, e.g., Schaffer (2016) and Wilson (2018) for relevant discussion of the similarities between grounding and causation and the associated kinds of explanation). Furthermore, we don't want to say that instead of aromaticity grounding the disposition to produce aromatic ring currents that this disposition *constitutes the essence of* aromaticity. This just seems implausible for the sorts of reasons that Bird highlights, i.e., the essence of aromaticity is compositional/structural, not dispositional. And indeed it seems unlikely that anything can explain that which is constitutive of its own essence (see, e.g., Jaag 2014). *Given* that aromaticity explains a disposition to produce aromatic ring currents, then, there are good reasons to believe that aromaticity *grounds* this disposition. In conjunction with the QDE conception of powers, it follows that aromaticity is a power.

So, from the plausible assumption that aromaticity explains the disposition to produce aromatic ring currents, it follows that aromaticity grounds the disposition to produce aromatic ring currents, which, in conjunction with the QDE conception of powers, implies that aromaticity is a power.

Furthermore, understanding the relationship between power and disposition as a *grounding* relationship accounts for the fact that properties and dispositions do *not* freely recombine, which is distinctive of the powers metaphysic and respects the spirit of Bird's anti-Humean emphasis on *Modal Fixity* (see also Tugby (2020, Sect. 5) for discussion of the relation between grounding theories of powers and (anti)Humeanism).

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How might one resist the above argument and deny that aromaticity grounds any dispositions? I'll now consider a *Humean*, an *Armstrongian* and a *Reductionist* objection to the argument that aromaticity grounds a disposition.

*Humean Objection.* The *Humean* might argue as follows: there are no metaphysically necessary connections between distinct existences, in particular, there are no metaphysically necessary connections between aromaticity and its associated dispositions; aromaticity and the disposition to produce aromatic ring currents are free to combine any which way. But grounding implies metaphysically necessary connections, if A grounds B, then it is metaphysically necessary that B exists if A exists; hence, there is no grounding relation between aromaticity and its associated dispositions.

The Humean might nonetheless concede that some generalization about the constant conjunction of aromaticity and certain dispositions is an axiom, or a theorem, of the best systematization of all local matters of particular fact throughout the universe and hence that it is a *law*. This Humean law would then allow for a Humean account

of the explanatory relation between aromaticity and, e.g., a disposition to produce aromatic ring currents. But lawhood, for the Humean, does not imply metaphysical necessity, so they can consistently maintain that a lawful connection obtains between aromaticity and certain dispositions and that there are no metaphysically necessary connections between aromaticity and those same dispositions. And from the denial of any metaphysically necessary connections between property and dispositions, the Humean can infer that no grounding relation obtains either and thus resist my argument above.

For the sake of this paper, however, I am assuming anti-Humeanism in the minimal sense that there are some metaphysically necessary connections in the world. In particular, I am assuming that there are metaphysically necessary connections between properties and the dispositions of individuals that instantiate those properties and, hence, that properties are not freely recombinable as per Lewisian Humean supervenience, for example. This seems like a minimal requirement for a powers metaphysic that wants to explain laws and modality and which, indeed, is what would seem to set the powers metaphysic apart from neo-Humeanism. So, to adopt this Humean *no necessary connections* line as a way of rejecting the above argument according to which aromaticity is a power would be to reject the key anti-Humean premise of the present discussion.<sup>8</sup>

*Armstrongian Objection.* Another way in which one might deny that aromaticity grounds its associated dispositions would be to adopt an Armstrongian view of laws as external governing relations. This way it could be maintained that there is some governing N-relation that holds between aromaticity and a disposition to produce aromatic ring currents, for example, and which supports the explanatory relationship between these properties and, hence, obviates the need to posit a *grounding* relation between the two. However, the nomic necessitation view is subject to various problems (see, e.g., Lewis 1983, 366; van Fraassen 1989, 96). Indeed, the shortcomings of the nomic necessitation view forms a large part of the motivation for the powers metaphysic, which seeks to locate the source of modality in the very natures of powerful properties, not in external governing relations or in brute facts about possible worlds. So, *given* that one is on board with powers (a fair assumption in the present context which is assuming QDE, a powers view, anyway) it would be very odd indeed to deny that aromaticity grounds its associated dispositions, and hence to deny that aromaticity is a power, in favour of positing an Armstrongian nomic necessitation relation between aromaticity and its associated dispositions to account for the explanatory relation between the two.

*Reductionist Objection.* Finally, one may mount a reductionist challenge to aromaticity's claim to explain a disposition to produce aromatic ring currents (or any other disposition), in the way required by the above argument. The reductionist may argue that since aromaticity supervenes on (perhaps because it is grounded by) fundamental properties, such as charge, mass, and spin, the characteristic dispositions associated

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<sup>8</sup> Powers theorists of a certain stripe might resist the "no necessary connections" line by *identifying* a power with its dispositions and thereby maintaining that power and disposition are not *distinct existences* after all. This won't help me though because identity is not a grounding relation and I am arguing that powers are properties that *ground* dispositions.

with aromaticity are not really explained by *aromaticity*, but are instead explained by the fundamental properties on which aromaticity supervenes.

But this strong reductionism is highly implausible because a disposition to produce aromatic ring currents, for example, is a respect of similarity that can be explained by aromaticity but not by the fundamental properties on which aromaticity supervenes. To see this, consider two aromatic compounds, *b* and *c* (benzene and chrysene, perhaps). Both *b* and *c* are disposed to produce aromatic ring currents when placed in a magnetic field. What explains this similarity? The obvious answer is that *b* and *c* are both aromatic; *aromaticity* is the property shared by *b* and *c* that explains their similarity with respect to the disposition to produce aromatic ring currents. The fundamental properties on which aromaticity supervenes, charge, mass, spin, etc. cannot explain this similarity because there are other properties that supervene on these exact same powers, such as *being a water molecule*, but which are *not* associated with a disposition to produce aromatic ring currents—there is a necessary connection between aromaticity and a disposition to produce aromatic ring currents, but not between, e.g., charge and a disposition to produce aromatic ring currents (similar remarks will apply to other dispositions/behaviours associated with aromaticity such as low reactivity and pi-stacking).

To put the point even more simply, a disposition to produce aromatic ring currents just doesn't seem to be present at the fundamental level.<sup>9</sup> We thus have good reason to believe that aromaticity is in fact explanatory and not eliminable in favour of more fundamental properties. (See Schaffer (2004) for similar considerations, which lead him to conclude that we ought to adopt the *scientific conception* of properties according to which the ontic properties are those that are or could be invoked in the scientific understanding of the world; more on this later.) To be clear, this anti-reductionism does not depend on any particular metaphysics of properties. The irreducibility of aromaticity and hence its status as an ontic macro property is independently plausible for the reasons just sketched (it is also assumed by Bird's argument by counterexample against pandispositionalism, see 2.3 above). But *in conjunction* with QDE, the claim that aromaticity is an ontic property implies that aromaticity is a power, for the reasons just discussed (aromaticity explains dispositions, it is plausible to think that this explanation is backed by the fact that aromaticity grounds those dispositions, and to ground dispositions is to be a power, according to QDE).

## 6 Macro powers and pandispositionalism

I have shown that QDE renders Bird's argument against pandispositionalism unsound and I have argued that, on the plausible assumption that aromaticity is an ontic macro property, QDE implies that aromaticity is a power. But the above argument should be readily extendible to a great many other chemical, biochemical and biological prop-

<sup>9</sup> Schaffer makes a similar point about the property of being a synapse: "Being a synapse, for instance, involves possessing the power to transmit a pulse from one neuron to another. No fundamental property has this power" (2004, 95). He also finds support for this kind of anti-reductionism in Kim: "Having a mass of 1 kilogram has causal powers that no smaller masses have, and water molecules, or the property of being water, have causal powers not had by individual hydrogen or oxygen atoms." (Kim, 1998, 108).

erties since all that argument assumed was that aromaticity *explained* certain dispositions of its bearers. What I have shown is that wherever there is a genuine explanation of a disposition in terms of a property, there will be good reason to believe that property is indeed a power, assuming, that is, the QDE account of powers and that one is minimally sympathetic to the anti-Humean, anti-Armstrongian powers metaphysic in the first place.

One might wonder just *how* far the above argument may be extended; I will now show that it can be extended very far indeed.

Bird argues against two distinct theses regarding the extent of the powers ontology. They are:

Pandispositionalism: All properties are powers.

And

MacroPT: Many or all macro properties are powers or clusters of powers, and such properties play a role in explaining important phenomena involving macro entities, such as causation, intentionality and free will.

Can the considerations thus far be extended in defence of MacroPT and/or pandispositionalism? If MacroPT is the thesis that many or all macro properties are powers *and* such properties play a role in explaining important phenomena involving macro entities, such as causation, intentionality and free will, then my arguments thus far do not support MacroPT because they do not support the second conjunct of that thesis; I have not been primarily concerned with the extent of the explanatory work to which powers may be put. Nevertheless, it is worth considering whether the arguments presented thus far may lend support to something close to MacroPT, namely:

Macro Powers: Many macro properties are powers.

For even Macro Powers is something that Bird denies and if Macro Powers were established, this would be an important step towards the very interesting and controversial thesis (and a thesis vociferously rejected by Bird) that is pandispositionalism.

As mentioned, I think that the argument for the powerfulness of aromaticity is general enough in form to be readily extendible to a great many other cases, perhaps this suffices to establish that *many or all macro properties are powers*. But one might object that to fully convince of this point, I ought to work through many more examples, which of course would be beyond the scope of this article. Instead, then, I will show how what has already been established may function to shift the burden of proof onto the powers theorist who would maintain that there are any properties that are not powers. This is dialectically interesting given that a key conclusion of Bird's arguments is that the burden of proof is on the powers theorist who would claim that many or most macro properties are powers and he thinks that this burden is very difficult to carry (2016, 357).

To see how this burden-shifting works, consider that for Macro Powers to be false, it would have to be the case that there are a great many (perhaps a majority of) ontic

macro properties that do not ground any dispositions (if there are no ontic macro properties, then Macro Powers is trivially true). But being both an ontic property and not grounding any dispositions is a very difficult conjunction for an entity to satisfy.

Plausibly, for a property to be *ontic* it must be the case that it explains at least one disposition, i.e., a property couldn't claim to be ontic if it didn't explain any dispositions. Bird himself seems to endorse this idea (indeed it is an assumption of his argument by counterexample against pandispositionalism (2016, 357; 2018, 258–59)), which is also echoed in Schaffer (2004) and in Kim (1998). This also chimes with the spirit of Armstrong's *Eleatic Principle*, roughly according to which contributing to the causal order of the world is the mark of the *real* (see, e.g., Armstrong 1978; 2004; Heil, 2003). In other words, it is plausible that for a property to be “invoked in our scientific understanding of the world” (Schaffer, 2004, 92), as per the account of ontic properties presently in play (see Sect. 2.1) it must explain at least one disposition. The first premise of my argument, then, is: For all X, if X is an ontic property, then X explains some disposition(s) of its bearers.

Now, as argued in Sect. 5, what *supports* the explanatory relation between property and disposition, according to the powers theorist, is *grounding* (see my responses to the *Humean* and *Armstrongian* objections, above). So, granting that a given property, P, is ontic and, hence, that P explains dispositions, it will follow, by my argument in Sect. 5, that P grounds the dispositions that it explains. The second premise of my argument is thus: For all X, if X explains some dispositions, then X grounds those dispositions. (If the property in question turns out not to be ontic, then it cannot be a counterexample to Macro Powers or pandispositionalism, which are theses about ontic properties only.)

The third premise is just a statement of QDE: For all X, if X grounds some dispositions, then X is a power. Pandispositionalism follows from these three premises:

P1) For all X, if X is an ontic property, then X explains some dispositions of its bearers. (this gains support from Bird (2016; 2018) as well as Schaffer's *scientific conception* of sparse/ontic properties (Schaffer 2004), see also Armstrong's Eleatic Principle (Armstrong 1978; 2004; Heil 2003)).

P2) For all X, if X explains some dispositions, then X grounds those dispositions. (From sympathy to powers and my argument in sec. 5.)

P3) For all X, if X grounds some dispositions, then X is a power. (From the QDE conception of powers).

Conclusion: For all X, if X is an ontic property, then X is a power, i.e., pandispositionalism is true.<sup>10</sup>

The discussion of aromaticity serves to highlight the plausibility of the claim that there are in fact ontic *macro* (i.e., non-fundamental) properties, which renders the

<sup>10</sup> Perhaps “explains” in P1 could be read as “partially explains”, in which case “grounds” in P2 and P3 would need to be read as “partially grounds”. But, as discussed above (sect. 3) I think the QDE-ist can remain open on the question of whether and to what extent powers fully or partially ground their associated dispositions (on this I am in agreement with Tugby (2021; 2022b)) and still retain the anti-Humean spirit of Modal Fixity. So, any consistent reading of full/partial explanation and full/partial grounding will suffice for the argument.



conclusion above highly non-trivial and antithetical to Bird's far more restrictive understanding of the extent of the powers ontology. The explanatory burden is thus on the denier of pandispositionalism and/or Macro Powers to refute one of P1-P3 in the argument above.

I defend P2 in Sect. 5, above. P3 is the assumption that QDE is true; I mention why one might endorse QDE at the outset of Sect. 3. But, to reiterate, strictly speaking, my aim in this paper is to show that *if* QDE is true, *then* pandispositionalism is true. Refutation of P1 would require significant argument. To refute P1 in the service of denying *pandispositionalism*, one would have to provide *at least one* example of a property that is both ontic and which does not explain any dispositions. And to refute P1 in the service of denying *Macro Powers*, one would have to provide *a great many* examples of ontic macro properties that do not explain any dispositions. But finding even one example of an ontic property that does not explain any dispositions is an incredibly tall order. This is because a property, P's, failing to be explanatory in this way would appear to be the mark of P's *not* contributing to the causal order of the world and hence not being "real". Put another way, a property's failing to explain any dispositions would seem to imply that we could not possibly detect that property because to be detectable a property must explain the disposition of its bearers to behave in such and such a way in such and such an experimental set up. But if a property is undetectable in principle, this seems as good a reason as any to deny its reality. All this, I think, is really just to add more credence to the *scientific conception* of ontic properties, which I am assuming for the purpose of this paper.<sup>11</sup>

I thus conclude that if QDE is true, then *all ontic properties are powers*, i.e., pandispositionalism is true.

## 7 Further clarifications and replies to objections

To end, I will further clarify my argument by addressing some potential objections.

***Humean and Armstrongian properties:*** Gerrymandered Armstrongian and Humean properties ground dispositions; Armstrongians and Humeans alike will agree that the property of being a thin quiddity (or collection of thin quiddities) subject to laws of nature, may fully ground a disposition/some dispositions. Though the Armstrongian and the Humean will disagree about the proper analysis of laws of nature, the point is just that they both can find properties, gerrymandered though they may be, that fully ground dispositions. But these gerrymandered properties are not

<sup>11</sup> A reviewer suggested that there may be some peculiar properties in physics that do not explain (and hence do not ground) any dispositions. The suggestion of *isospin* was floated. But it seems to me that isospin plausibly explains the disposition of its bearers to follow a certain trajectory though a Stern-Gerlach set-up, for example. Again, and in general, it seems that if a property is detectable, it must explain some disposition or other. And it is plausible that to be ontic a property must be detectable. Perhaps one could cite some exotic physics properties that are not detectable, but then I would like to know why we should think of them as ontic or indeed how we can know about them if they are not detectable. This may be an interesting debate for another time which is as much an issue for the conception of ontic properties as it is for the present argument that QDE implies pandispositionalism.

powers so there must be something wrong with my argument according to which any property that explains and hence grounds a disposition is a power.

This objection ultimately misses the mark against my arguments in this paper. My argument in Sect. 6 above aims to establish the following conditional: For all X, if X is an ontic property, then X is a power (i.e., all properties are powers which is to say that pandispositionalism is true). And, more broadly, the aim of this *paper* is to establish that if QDE is true, then pandispositionalism is true, which follows from the argument in Sect. 6 because QDE is an assumed premise in that section's argument for pandispositionalism. The objection says just that gerrymandered Armstrongian or Humean properties ground dispositions but are not powers. This is an objection to QDE, according to which powers are properties that ground dispositions. My aim, however, is to show that *if* QDE is true, then pandispositionalism is true; my argument for *this* conclusion is not affected by the present objection because the falsity of QDE would only falsify the antecedent of this conditional leaving the truth of the conditional itself unaffected.

One might also take the objection from gerrymandered properties to cast doubt on in the argument of Sect. 6 because gerrymandered Armstrongian and Humean properties are examples of properties that ground dispositions but which are not *ontic*. This does not affect my argument because my argument relies only on the claim that if a property X is ontic, then it grounds a disposition (from P1 and P2) and it says nothing about the other direction (if P grounds a disposition then P is ontic), which is what the objection casts doubt on.

While I think that the objection from gerrymandered Humean and Armstrongian properties strictly misses the mark against my arguments in this paper, perhaps there is still cause for concern if it indeed falsifies QDE, since then the conditional for which I am arguing—*if QDE, then pandispositionalism*—would be proved to be purely academic and this paper would be less interesting. In response to this it seems reasonable to incorporate into QDE the claim that only ontic properties are candidate powers. It could then be maintained that gerrymandered Humean and Armstrongian properties, if there were such things, would not count as ontic, and hence that they would not after all count as powers, according to QDE.<sup>12</sup>

**Triviality and fair naming:** Another thing one might worry about is an air of triviality. One might, perhaps somewhat uncharitably, interpret my argument as merely establishing that the ontic properties are those that may feature in scientific explanations and that's just what *powers* are. But there is nothing trivial about my conclusion (*if* QDE is true, then pandispositionalism is true) because to get there, I had to make some substantive assumptions that only an anti-Humean with a penchant for powers would accept (this is the point of my responses to the Humean and Armstrongian objections in Sect. 5—the argument in Sect. 6 just generalizes that presented in Sect. 5). So, the interest lies in drawing out the implications of a particular interpretation of the powers metaphysic. Relatedly, one might complain that the view that I call “pandispositionalism” and which I argue follows from QDE is not really *pandispositionalism* because properties with non-modal essences that ground dispositions

<sup>12</sup> My thanks to a reviewer for this suggestion, which is far more elegant than what I had originally opted to say here!

are not really powers. But this is an objection to *calling* QDE a powers view, which again misses the point of my argument which primarily aims to establish that if QDE is the true account of *powers*, then pandispositionalism is true. Nevertheless, there is a case to be made for this nomenclature: the point of the replies to the Humean and Armstrongian objections in Sect. 5 was to show that one needs to be antecedently sympathetic to powers for my argument to go through. These replies thus suggest that QDE really is a powers view of properties, since unlike Armstrongianism and Humeanism it locates the ultimate source of modality in properties themselves. And the point of discussing aromaticity and the reply to the reductionist objection was to show that some *macro* properties have just as much claim to be powers as fundamental properties do, so the pandispositionalism that follows from QDE is highly non-trivial. I maintain, then, that the view that I call “pandispositionalism” is non-trivial and is fairly named.

**Characterizing anti-Humeanism:** Azzano (2019) has recently advocated a view according to which (roughly speaking) realism about powers is the view that properties are full grounds of dispositions, which would seem to add credence to my claim that QDE is in fact a powers view. However, Vetter (2020) has responded that this cannot be the proper story about how to characterize anti-Humeanism *in general* because, and related to what was said previously, gerrymandered Humean and Armstrongian properties may serve as full grounds for dispositions. This is an interesting debate but is strictly orthogonal to my current concerns. I am not interested in providing a general characterization of anti-Humeanism, rather, I am interested in showing that if QDE is true, then pandispositionalism is true—QDE is assumed for the sake of argument and is assumed (not unfairly I suggest) to be a powers view. Perhaps Vetter’s point about gerrymandered properties is threatening to QDE, but as above, a plausible move would be to maintain that QDE is a thesis just about ontic properties and that these gerrymandered properties are not ontic.

**The scientific conception of ontic properties:** Finally, Vetter (2018; 2020) makes a related criticism of the *scientific conception* of ontic properties that may appear to be of concern for my argument. Vetter argues that the view according to which the ontic properties are just those that feature in scientific explanations suffers because what counts as a scientific explanation is highly contingent and varies over time, but we do not want to say that which properties count as ontic is contingent and variable. The most plausible formulation of the scientific conception thus has it that the ontic properties are those that *could possibly* feature in scientific explanations, at least this way there is no temporal or modal variation in what gets to count as an ontic property. The problem with this approach, however, is that it looks far too permissive because surely even highly disjunctive, conjunctive or otherwise gerrymandered properties, which we do not want to say are ontic, *could* feature in scientific explanations (Vetter, 2020, Sect. 3). But again, this is not strictly speaking a problem for my argument because it is a challenge to the following conditional: if X could feature in a scientific explanation, then X is ontic. The part of my argument that is most closely related to this issue regarding the scientific conception of ontic properties is premise 1 of my main argument in Sect. 6:

P1) For all X, if X is an ontic property, then X explains some dispositions of its bearers.

I do invoke the scientific conception of properties, and the closely related Eleatic principle, in support of this conditional. But the support comes just from the idea that *if* a property is ontic, *then* it makes a difference to the causal order of the world or could feature in scientific explanations, where I take either making causal difference or potentially featuring in a scientific explanation to imply explaining dispositions (see my arguments in Sects. 5 and 6). I do not rely on the reverse conditional—if X could feature in a scientific explanation, then X is ontic—on which Vetter’s argument casts doubt. So again, while on first glance, Vetter’s criticism of the scientific conception of properties may seem damaging to my argument, it is, strictly speaking, orthogonal to my claims in this paper.

## 8 Conclusion

I conclude, then, that if QDE is true, then pandispositionalism is true. What’s more, there are independently plausible reasons for thinking that there exist ontic *macro* properties, such as aromaticity. QDE implies that these macro properties are powers too. This is an interesting enough result in itself, but if QDE turns out to be the only viable account of powers, as some think is indeed the case, then the conclusion becomes even stronger: if the *powers metaphysic* is true, then pandispositionalism is true. And of course, the powers metaphysic is gaining ever increasing support, so we are not far off having a very strong case for the straightforward conclusion that pandispositionalism is true *simpliciter*.

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## Declarations

**Conflict of interest** None.

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