Subsystems as Aspects

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Draft of: February 28, 2026

Abstract

This paper bridges two seemingly unrelated ideas: (1) a metaontological framework for talking about "portions of reality" without committing to a specific object-property analysis of these "portions", and (2) David Wallace's subsystem-recursive view of physical theories. Metaontologists debate whether mereological disputes over composite objects are merely verbal (Hirsch, 2005) or reflect genuine disagreements about how the world is (Sider, 2009). Both sides often pose this debate as being about "whether there is an objectively correct way to carve reality into objects and properties", but they treat this "portion" talk as merely metaphorical. I show how we can make it precise by interpreting portions of reality as aspects of facts, as understood in Rayo (forthcoming). The resulting formalism is neutral with respect to any particular object-property analysis of those "portions". This same formalism also yields an interpretation of Wallace's subsystem structures by identifying each physical subsystem in a subsystem structure with a corresponding aspect, thereby supporting the thesis that the physical treatment of subsystems can remain neutral in exactly the same way, which provides fresh support to structural realist positions defended in the philosophy of physics (Ladyman and Ross, 2007; Wallace, 2022).

1 Introduction

This paper grew out of a purely *metaontological* question: How can we talk about a certain "portion of reality" without committing to a specific object-property analysis of it? Many metaphysical debates, like that between *mereological nihilists* and *mereological universalists*, revolve around whether a situation in which some particles are arranged table-wise is one in which *there is an additional thing* they compose, namely a table, with nihilists[1] denying it (Van Inwagen, 1995) and universalists

[1] Even though I cite Van Inwagen (1995) as an example of a *nihilist*, this isn't entirely right, see footnote 3.

affirming it (Lewis, 1991). A bit more recently, there has been a discussion about whether this dispute and related ones are *merely verbal* or whether they reflect genuine disagreements about *how the world is*, with philosophers like Hirsch (2002; 2005; 2009) arguing for the former and Sider (2009) arguing for the latter. Let's call the former view *deflationism* and the latter *inflationism*.[2]

Often times, both inflationists and deflationists feel compelled to frame this discussions as being about whether there is an objectively correct way to "carve portions of reality" into objects and properties—for instance on whether a "chairish portion of reality" constitues a chair, or whether it is *merely* a collection of particles arranged chair-wise. Indeed, Hirsch (1978) already frames discussions like this in terms of when we are compelled "to "dignify" certain portions of reality as unitary things". But this talk seems to be in tension with the spirit of deflationism: if a "portion of reality" is a *thing*, then this already favours the universalist in a sense, and if "it is not a thing", then what "is" "it"? Sider (2022) already points out that this talk about portions of reality "is in dire need of clarification", and provides a model inspired by this talk, but one which somewhat disfavours the deflationist, as we will see in §2. In this paper, I show another way in which portion-of-reality talk can be articulated in a way which is more faithful to the deflationist spirit. The key idea, which I develop in §2, is to interpret portions of reality as *aspects of facts*, a notion developed by **rayoUltraThinConceptionObjecthood** for altogether different reasons. I then draw upon this notion, formalize it in a higher-order logical framework, and show how it can allow us to talk about portions of reality in an way which is neutral on their object-property analysis.

Additionally, the resulting framework can be applied to provide an interpretation of David Wallace's (2022) *subsystem structures*, a formalism developed to defend an interpretative view of physical theories according to which they should primarily be interpreted as modelling *subsystems* of the universe instead of the universe as a whole. I provide a brief overview of Wallace's framework in §3, and then show in §4 how each subsystem can be seen as a *portion of reality* as understood in the previous section. I will call this the *aspects interpretation* of subsystem structures. This correspondence supports the thesis that the physical treatment of subsystems can remain neutral with respect to their object-property analysis. More generally, interpreting physics as talking about subsystems conceived as aspects of facts shows a way for "structural realists" (Ladyman and Ross, 2007; Wallace, 2022b) to make sense of their view that physics doesn't commit us to any particular object-property analysis of reality—or, at least, not to one *to the exclusion of others*. This, in turn, also allows us to see the "portions of reality" in the deflationist-inflationist debate as physical subsystems, providing another angle of analysis to this debate. Thus, the paper provides new support for *both* the deflationist view in metaontology and the structural realist view in philosophy of physics. I conclude in §5 by discussing the implications of this framework for both debates.

[2]Sometimes "inflationism" is used to refer to a different view, according to which there are more objects than we might think, but I am not using it in this sense here. Rather, inflationism might be seen as the view that there are more *metaphysically substantive disagreements* than we might think.

2 Metaontology: Portions of Reality and Aspects

Some debates in metaphysics often revolve around whether certain purported entities—like tables—*really* exist, or whether there are instead *only* particles arranged table-wise. Indeed, *mereological nihilists* claim that there are no composite objects at all, only particles in various arrangements (Van Inwagen, 1995).[3] *Mereological universalists*, by contrast, affirm that whenever there are some particles (or objects) standing in certain relations, there is a further, composite object (Lewis, 1991). Of course, a range of positions lies between these two extremes (Markosian, 1998), but the nihilist–universalist debate offers a helpful starting point for our investigation.

Some metaphysically *deflationist* philosophers such as Eli Hirsch (2002; 2005; 2009) argue that these sorts of existence debates are often *merely verbal*: each side expresses the *same* facts in a slightly different language, but there is no substantive disagreement about what the underlying facts are. For example, Hirsch contends that when the universalist describes one fact by saying "There is a table here," the nihilist might describe *the same fact* by saying "Some particles are arranged table-wise here", so their disagreement is "merely verbal". Metaphysical *inflationists* like Sider (2009), by contrast, are more inclined towards views that favor one of the sides in these debates: *even if* both the nihilist and the universalist are describing the same fact, at most one of them is describing this fact in the "metaphysically correct" way, and that correctness is *determined by the world*.[4]

Often times, both inflationists and deflationists feel compelled to frame their discussion precisely in these terms: as being about whether there is an objectively correct way to "carve portions of reality" into objects and properties. Indeed, Hirsch (1978) already frames discussions like this in terms of when we are compelled to "to "dignify" certain portions of reality as unitary things", while Sider (2022) has framed deflationism as the thesis that "whether a given portion of reality counts as an object depends on how we're carving up reality into objects". Yet this talk seems to be in tension with the spirit of deflationism: if a "portion of reality" is a *thing*, then this already favours the universalist in a sense, and if "it is not a thing", then what "is" "it"? Sider (2022) already points out that this talk about portions of reality "is in dire need of clarification", since it appears to involve quantification which at least one side of the debate cannot accept—namely, the nihilist. Thus, the situation seems to favour the universalist, in some sense, and thereby also the inflationist.

Sider (2022) goes on and analyzes portion-of-reality-talk in terms of *carving models*. These models are tuples $\langle W, B, R \rangle$, where W is a set of possible worlds, B is a set of (pre-objectual) "building blocks" of reality, and R is a subset of $\mathcal{P}(B)$. Intuitively, R is a "carving" of B into the objects "formed" by these pre-objectual building blocks. This carving might differ between the universalist

[3] Even though I cite Van Inwagen (1995) as a paradigmatic example of a *nihilist*, he is more precisely an *organicist*, denying the existence of any non-living composite objects. For current purposes, however, this distinction is not crucial.

[4] There is another kind of inflationist, who flatly denies that the nihilist and the universalist are talking about the same fact even as interpreted in their own "idiolect". I don't think this position is implausible, but I won't consider it for the purpose of this discussion.

and the nihilist: the universalist might let $R_{\mathrm{U}} = \mathcal{P}(B)$, while the nihilist might let $R_{\mathrm{N}} = \{\{b\} \in \mathcal{P}(B) \mid b \in B\}$. Sider interprets this model such that a *proposition* is a set of worls $p \subseteq W$, and a *concept* is a function c from worlds $w \in W$ to sets of (candidate) objects $c(w) \subseteq \mathcal{P}(B)$. Here, propositional entailment is understood in the usual way, i.e. such that p entails q iff $p \subseteq q$, and *concept entailment* is understood such that c *concept-entails* c' iff $c(w) \subseteq c'(w)$ for all $w \in W$. Lastly, for any concept c, the proposition *that there are* c*'s* is true at w iff $R \cap c(w) \neq \varnothing$. Under this setup, the nihilist and the universalist might have a common stock of propositions and concepts with a common entailment relation between them, and each maintain their own quantifier "there is", but the nihilist must accept cases of "trans-ontic entailment" where necessarily, each c is c', but c fails to *concept-entail* c'.

However, Sider's carving model arguably tilts matters toward the universalist (and thus the inflationist) once we take it at face value. First, the model includes an *unrelativized* domain $\mathcal{P}(B)$—the set of all subsets of B—which the universalist can legitimately see as her "domain of entities", whereas the nihilist cannot. A deflationist might see this unrelativized domain as a mere modeling artifact, but it is hard to resist the temptation of seeing it as an actual domain of objects. Second, that this temptation is exhacerbated by the fact that R can be treated like any other concept by setting $r(w) = R$, so one is tempted to describe elements in R_{U} that are missing in R_{N} simply as *objects* recognized by the universalist but not by the nihilist—again favoring the universalist. Third, to the extent that the two sides share a notion of entailment in W, the nihilist is forced to concede a gap between concept-entailment and her own notion of necessary material implication in ways the universalist is not. Collectively, these features threaten the purported neutrality of the model.

The deflationist can try to make sense of this talk in a number of alternative ways, but all of these attempts seem to also bring her trouble. For instance, she may talk about *regions of spacetime* to capture portion-of-reality-talk (Van Inwagen, 1995; Hirsch, 1978), but that commits one to an ontology of spatiotemporal regions which themselves may be construed as fusions of spacetime points—precisely the kind of mereological baggage the nihilist was keen to avoid.[5] Alternatively, she may use *plural quantification* over particles (Boolos, 1984), recasting "portions of reality" as pluralities of particles. But this move arguably grants the nihilist's analysis an advantage: the question now becomes a question of whether one of the following two possible articulations of a plurality of particles aa is the *correct* one: (i) the particles aa or (ii) aa together with all fusions of them. The answer here is obvious. More generally, if one tries to resolve portion-of-reality-talk by adopting a metaphysically correct object-property analysis from the outset, that analysis will favor whichever side it happens to match (universalist, nihilist, or some other side thereof), thereby undermining the deflationist's attempt at neutrality and ultimately favoring the inflationist. Thus, it seems all cards are stacked against the deflationist in this case.

[5] Moreover, some archetypal universalists—e.g. Lewis (1991)—sometimes treat their *entire* (concrete) ontology as nothing but spatiotemporal regions composed by spacetime points.

When confronted with such a situation, the deflationist might be inclined to simply give up on this talk altogether and default on some other semantic analysis on neutrality. Indeed, Hirsch (2009) eschews this talk altogether, and articulates his claim as the claim that the nihilist and the universalist might be conceived as speaking "alternative languages"—languages that express the same set of characters[6], but distributed differently over their sentences. While this allows one to say that a universalist's "there is a table here" and a nihilist's "there are particles arranged table-wise here" *express* the same fact in different languages, it fails to capture the sense in which they also single out *the same portion of reality*. After all, one might want to say that when the universalist says "Here is a table. It's round, wooden, ..." and the nihilist replies "Some particles are arranged table-wise here. They form a round shape, are arranged wood-wise...," they are talking *not only* about the same fact, but about the same *chunk* of reality. Hence, if Hirsch is correct in claiming that universalists and nihilists have equivalent pictures of the world,[7] then that equivalence runs deeper than the idea of them asserting the same facts in different vocabularies.

2.1 Aspects of Facts

A promising way to make "portions of reality" talk precise, yet remain neutral on specific object-property analyses, emerges in **rayoUltraThinConceptionObjecthood** through the notion of *aspects of facts*. Rayo develops this notion in a discussion with Linnebo (2018) on when a singular term (like '0') truly *refers* to an object and, relatedly, what it is for something to *be* an object. In a highly compressed form, Linnebo argues that a term c in language L with sentential interpretation $[\![\cdot]\!]$ refers if and only if:

(i) $[\![\cdot]\!]$ respects logical entailments in a free logic,

(ii) $[\![\cdot]\!]$ assigns $\ulcorner \exists x(x = c) \urcorner$ a true proposition, and

(iii) $[\![\cdot]\!]$ interprets L such that c is governed by a predicative abstraction principle based on some partial equivalence relation $\sim$, and a suitably positioned agent with an adequate grasp of $\sim$ uses L as interpreted by $[\![\cdot]\!]$.

Rayo, by contrast, contends that only the first two conditions are required for genuine reference. To justify this position, he proposes a picture where both singular-term reference (to objects) and predicative reference (to properties) are understood in terms of *rendering salient* certain *aspects of facts* through networks of connections. More concretely, one might analyze the fact [Socrates died] by putting it in relation to other facts, as in the following table:

[6] A *character* is a function from contexts to sets of possible worlds.

[7] I must confess I am *not* exactly a deflationist in Hirsch's sense: I wouldn't use the term "merely verbal dispute" to describe the situation between nihilists and universalists. Nevertheless, Hirsch's metaontological view bears some resemblance to mine, which makes these issues worth discussing.

	[Socrates died]		[Hypatia died]		[Aristophanes died]
	relates to		*relates to*		*relates to*
(A)	[Socrates is wise]	*as*	[Hypatia is wise]	*and as*	[Aristophanes is wise]
	and		*and*		*and*
	[Socrates argues]		[Hypatia argues]		[Aristophanes argues]
	[Socrates died]		[Socrates is wise]		[Socrates argues]
	relates to		*relates to*		*relates to*
(A^T)	[Hypatia died]	*as*	[Hypatia is wise]	*and as*	[Hypatia argues]
	and		*and*		*and*
	[Aristophanes died]		[Aristophanes is wise]		[Aristophanes argues]

Here, the first analysis (A) picks out the object SOCRATES, while the second complementary analysis—given by the *transpose* (A^T) of (A)—picks out the property HAVING DIED. Together, they constitue a *decomposition* of the fact [Socrates died] into these two aspects. But this is not the only way of decomposing [Socrates died]. For instance, one might also analyze it in terms of its relation to other facts by putting it into the following network of relations and its corresponding transpose:

	[Socrates died]		[the Symposium occured]		[WWII occured]
	relates to		*relates to*		*relates to*
(B)	[Socrates's death saved Athens' youth]	*as*	[the Symposium saved Athens' youth]	*and as*	[WWII saved Athens' youth]
	and		*and*		*and*
	[Socrates's death was tragic]		[the Symposium was tragic]		[WWII was tragic]

Here, we have analyzed the same fact in terms of SOCRATES'S DEATH (via B) and HAVING OCCURRED (via the transpose B^T), instead of SOCRATES and HAVING DIED. Analyzing a fact under this picture can be seen as akin to decomposing a vector into its basis components: once the basis (or mode of analysis) is picked, there is an objective fact of how the vector is decomposed (or the fact analyzed), but the choice of basis (or mode of analysis) is itself conventional.

To see why this is helpful for making sense of portion-of-reality-talk, notice that this talk suggests the nihilist and the universalist "describe the same fact" but draw different metaphysical lines—one posits a *singular object* "the composite," the other posits a *plurality* "those particles" as the *portion of reality* they are talking about. On Rayo's ultra-thin picture, both are legitimate ways of carving or "analyzing" the same fact(s) along different dimensions. The universalist focuses on THE COMPOSITE OF PARTICLES and IS A TABLE, while the nihilist focuses on THE PARTICLES and ARE ARRANGED TABLE-WISE. If the only difference is a choice of which aspects one highlights, then indeed they are talking about the same situation in distinct but equally correct bases.

Yet portion-of-reality talk suggests more than just the "same fact" being analyzed differently: it suggests that the analyses that yield THE COMPOSITE OF PARTICLES and THE PARTICLES are *equivalent* in some sense, even if they yield items with different semantic categories—namely singular objects and pluralities. In Rayo's framework, that portion can be recognized as what is common to both analyses once we "forget" the difference between singular vs. plural terms, or, more generally, once we "forget" the difference between different semantic categories and consider them as belonging to the same category of *aspects of facts*. Here is where my proposal comes in.

My proposal is, first, that we interpret Rayo's talk about aspects of facts in a more literal way—one that "collapses" distinctions between different semantic categories of these aspects; and second, that we interpret the deflationist's talk about "portions of reality" as talk about aspects of facts. Thus, I propose two things:

(1) We should think of *aspects of facts* much in the same way properties are *aspects of objects*. Higher-order logic gives us the resources to make sense of this.

(2) Given (1), *portions of reality* are best understood as *aspects of facts* of a certain kind.

The rest of this section is devoted to developing these two points, but first, we need a brief overview of higher-order logic. The reader who is already familiar with this framework can skip to §2.3.

2.2 Higher-Order Logic

Higher-order logic (HOL) is a framework that extends first-order logic by introducing a *type system* for every expression in the language, as well as by enabling quantification over these types and allowing λ-abstraction. It has become increasingly popular in metaontological and modal debates (Bacon, 2018; Rayo, 2020; Dorr, Hawthorne, and Yli-Vakkuri, 2021; Bacon and Dorr, 2024). The two most basic types are e (for singular terms, such as names, definite descriptions, or functional terms) and t (for sentences or formulas). We can also include a type ee to handle *plural* terms (e.g. "the particles," "the cats"). From these basic types, we build *functional* types $\sigma \to \tau$, whose expressions combine with expressions of type σ and yield expressions of type τ. For instance, a monadic predicate like "is a dog" has type $e \to t$, since it combines with a singular term like "Fido" (type e) to form a sentence like "Fido is a dog" (type t), while a *plural* predicate like "are arranged table-wise" has type $ee \to t$. The types of other expressions are assigned in a similar way, as shown in the table below:

Expression	Type
Names	e
Sentences and Formulas	t
Monadic Predicates	$e \to t$
Operators ($\neg$, $\Diamond$, $\Box$, etc.)	$t \to t$
Connectives ($\wedge$, $\to$, etc.)	$t \to (t \to t)$
$\vdots$	$\vdots$

In addition to assigning types, HOL makes three central additions to first-order logic. First, it provides an *identity* relation at every type: for any expressions a and b of type σ, $\ulcorner a =_\sigma b \urcorner$ is a sentence. Thus we can write $\ulcorner a =_e b \urcorner$ ("Fido is Bruno") or $\ulcorner aa =_{ee} bb \urcorner$ ("these particles are those particles"), and so forth. Second, it allows *quantification* over every type: if A is an expression of type $\sigma \to t$, we may form $\ulcorner \exists_\sigma A \urcorner$ and $\ulcorner \forall_\sigma A \urcorner$. For instance, if '$F$' is a predicate of type $e \to t$, we may write '$\exists_e F$' to say "something is F", and if 'G' has type $ee \to t$, we might write '$\exists_{ee} G$' to say "some things (plurally) satisfy G." Finally, HOL supports λ-*abstraction*, permitting the formation of functions by "abstracting away" from expressions: if A is an expression of type τ, we may form $\ulcorner (\lambda x^\sigma. A) \urcorner$, which is an expression of type $\sigma \to \tau$. For example, from '$\neg Fx$' (say, "*it* isn't a dog") we may form '$\lambda x^e. \neg Fx$' ("isn't a dog"), or more involved expressions at higher types. For brevity, we often write $\ulcorner \forall_\sigma (\lambda x^\sigma. A) \urcorner$ and $\ulcorner \exists_\sigma (\lambda x^\sigma. A) \urcorner$ as $\ulcorner \forall x^\sigma A \urcorner$ and $\ulcorner \exists x^\sigma A \urcorner$, respectively. Types are also often omitted when they can be inferred from context.

Semantically, it is often said that expressions of type e and t denote *objects* and *propositions*, respectively, whereas expressions of type $\sigma \to \tau$ denote *functions* from the interpretation of type σ to that of type τ. While a helpful rough guide (e.g. the value of "is a dog" takes the value of "Fido", the dog itself, and yields the value of "Fido is a dog", a proposition), this picture can be misleading if taken too literally—especially for philosophers who reject robust object-level ontologies of "properties" or "propositions." For instance, a nominalist higher-order logician might be happy with sentences like

$$\exists X^{e \to t} \forall y^e (Xy \leftrightarrow Xy) \ \wedge\ \neg \exists x^e \, \text{property}(x),$$

which involves type-($e \to t$) quantification—i.e. "quantifying over properties"—but denies that the predicate "property" picks out anything if read in her sense. The reader is encouraged to consult Bacon (2023, §0.5) and Rayo and Yablo (2001) for a more in-depth discussion of these subtleties when interpreting higher-order logic and higher-order quantification.

My proposal to treat *aspects of facts* using a certain kind of expression in a higher-order framework should be read on the same spirit. As we will see, I will say that aspects have type $t \to t$ and I will quantify over them; but in doing this, I do not mean to suggest that this can be read as first-order quantification over some particular abstract entities.[8] Rather, I am exploiting the fact that HOL allows *different kinds* of quantification. For convenience, I will use language which suggests that aspects are like "things," but one should think of this as "loose talk" (in the sense of Bacon, 2023, §0.8) for the sake of exposition.

2.3 The Framework of Aspects: A Preliminary Overview

With this background in place, we can now return to the idea of *aspects of facts*. The guiding proposal is that aspects of facts are related to facts in the same way that properties (i.e. aspects of objects) relate to objects. In type-theoretic terms, if properties are of type $e \to t$ (because they map objects to propositions), then aspects of facts should be of type $t \to t$ (since facts themselves are described by sentences). This setup deviates somewhat from Rayo's original picture[9]—where aspects like SOCRATES or HAVING DIED may carry different types depending on the "dimension" of analysis—but it is precisely the price we have to pay to make sense of portion-of-reality-talk in a deflationist-friendly way.

Concretely, on this approach, both SOCRATES and HAVING DIED are treated as type-($t \to t$) operators that extract or "filter" a certain strand common to many facts. For instance, SOCRATES captures what is common to facts like [Socrates died], [Socrates is wise], [Socrates argues], while HAVING DIED captures what is common to facts like [Socrates died], [Hypatia died], [Aristophanes died], and so forth. Admittedly, this analysis "deletes" some information about the semantic dimension involved (e.g. object vs. property), but it facilitates our goal of letting "portions of reality" be recognized in a way that is neutral to object-property analyses.

But note that merely saying "aspects are type-($t \to t$) operators" does not in itself specify *which* type-($t \to t$) operators count as aspects. To make progress, we can note that there is a notion which already captures what these stands of facts seem to share: the notion of *subject matter* as understood by Lewis (1988) and Yablo (2014). According to this notion, a subject matter α is an operator that takes a proposition p and returns the part of p relevant to them. For instance, if $\alpha_{\mathsf{Socrates}}$ is the subject matter that concerns Socrates, then feeding it [Socrates died and Hypatia is wise] should yield [Socrates died]. This captures the sense in which $\alpha_{\mathsf{Socrates}}$ unifies facts like [Socrates died], [Socrates is wise], [Socrates argues], and so forth, in that they are all *about Socrates*—i.e. they all satisfy $\alpha_{\mathsf{Socrates}}(p) = p$. Relatedly, we can think of α_{died} as the subject matter that concerns dying, which unifies facts like [Socrates died], [Hypatia died], [Aristophanes died], and so forth.

[8] I also do not mean to *block* such an interpretation. If one wants to interpret aspects as abstract entities, they are free to do so. But the reader who chooses to do it should not hold me accountable for any of the consequences that follow *only* from this interpretation.

[9] Although Rayo admits that this distinction is not a *metaphysical* one: "The difference between objects and properties is not a difference of "metaphysical character": no criterion based on purely metaphysical considerations could be used to distinguish between an object and a property." (**rayoUltraThinConceptionObjecthood**)

Turning to the nihilist–universalist dispute clarifies why this is helpful. Consider a scenario where the universalist declares "There is a table" while the nihilist says "Some particles are arranged table-wise," and, following Hirsch (2009), we interpret them as describing the *same* fact in slightly different languages. Often, we care not only that a table (or a plurality) exists, but also about that *particular* table or plurality—i.e. we want to target the *same portion of reality* in each speaker's vocabulary. Suppose the universalist uses a singular term a for the table, whereas the nihilist uses a plural term aa for its constituent particles. Each can then assert parallel claims:

Universalist	**Nihilist**
Wa ("a is wooden")	$WWaa$ ("aa are arranged wood-wise")
Ra ("a is round")	$RSaa$ ("aa form a round shape")
⋮	⋮

The deflationist would say both pairs of statements express the *same* content—just phrased in different variants of English: "Universalese" and "Nihilese." But we can say more: the universalist and the nihilist are not only talking about the same fact, but about the same *portion of reality*. In our framework, we formalize that portion as an aspect $\alpha : t \to t$. Intuitively, α filters out claims unrelated to the "tabley portion". So if the universalist also singles out a "chairish portion" with a singular term b, and the nihilist has bb for its particles, α should ignore that separate portion. For instance, we should have:

$$\alpha\big([\![\text{`}Wa \wedge Wb\text{'}]\!]_{\text{U}}\big) \;=_t\; [\![\text{`}Wa\text{'}]\!]_{\text{U}} \text{ and equivalently } \alpha\big([\![\text{`}WWaa \wedge WWbb\text{'}]\!]_{\text{N}}\big) \;=_t\; [\![\text{`}WWaa\text{'}]\!]_{\text{N}},$$

where $[\![\ldots]\!]_{\text{U}}$ and $[\![\ldots]\!]_{\text{N}}$ are the Universalese and Nihilese interpretation functions, respectively. In other words, α captures precisely the "tableish aspect", leaving aside anything about the "chairish aspect". In so doing, we gain a means of saying that both speakers isolate the *same portion of reality* α even though they use different object-property schemes to analyze it.

To see how this picture is deflationist-friendly, note that the aspect α is not an entity (type e) which would mean "a is wooden" is analyzed as the *object* $[\![\text{`}a\text{'}]\!]_{\text{U}}$ having the *property* $[\![\text{`is wooden'}]\!]_{\text{U}}$; neither is it a *plurality* (type ee) which would mean "aa are arranged wood-wise" is analyzed as the *plurality* $[\![\text{`}aa\text{'}]\!]_{\text{N}}$ having the *plural property* $[\![\text{`are arranged wood-wise'}]\!]_{\text{N}}$. Rather, it is an *aspect* (type $t \to t$), and facts "about the tabley portion of reality" aren't analyzed beyond the fact that they comprise the range or image of α. It is also worth noting that it doesn't favor the universalist in the same way Sider's carving models do, since it does not contain an "unrelativized" domain of objects. There is, perhaps, an "unrelativized" domain of aspects, but neither the universalist nor the nihilist recognizes this domain as her domain of objects. Thus, this picture eliminates any suggestion that the universalist is getting at some "natural boundary" of what counts as an object.

2.4 Formalizing Aspects

This usage of type $t \to t$ operators as aspects suggests a set of axioms that we can phrase in the language of higher-order logic (HOL), making use of an entailment relation $\leq$.[10]

(A1) **Weakening.** $p \leq \alpha(p)$.
What p says in total entails what p says about α.

(A2) **Monotonicity.** If $p \leq q$, then $\alpha(p) \leq \alpha(q)$.
If p entails q, then the α-filtered part of p entails the α-filtered part of q.

(A3) **Identity.** $\alpha(\alpha(p)) = \alpha(p)$.
Applying α again does nothing if you've already filtered p once.

I do not claim that these axioms are exhaustive, but they capture the core idea that an aspect α is a filter of propositions. The formalism is meant to be general enough to apply to any pair of speakers with different object-property analyses of the same aspects, not just universalists and nihilists, so any axioms beyond these would have to be justified on a case-by-case basis. Now, of course the nihilist and the universalist can do more than just single out *one* aspect α. Rather, they can single out a *collection* of aspects $\mathcal{A}$, corresponding to their conception of the "portions of reality" that the world contains. This is captured by the notion of a *system of aspects*:

> ***System of Aspects***. A *system of aspects* is an item $\mathcal{A}$ of type $(t \to t) \to t$ such that any α of type $t \to t$ which satisfies $\mathcal{A}$—i.e. such that $\mathcal{A}(\alpha)$—also satisfies the axioms (A1)–(A3). We say of an aspect α that it is *in* the system of aspects $\mathcal{A}$ iff $\mathcal{A}(\alpha)$.

We might imagine that the nihilist and the universalist have each their system of aspects $\mathcal{A}_{\text{N}}$ and $\mathcal{A}_{\text{U}}$, respectively, corresponding to what they take to be the "portions of reality" that the world contains. To get a sense of what these aspects are, one might imagine, for instance, that the nihilist constructs $\mathcal{A}_{\text{N}}$ "in steps":

1. First, single out a collection aa of particles and determine all the propositions corresponding to the claims that can be made about them. Let P_{aa} be (the set of) these propositions.

2. Next, define the aspect α_{aa} which sets $\alpha_{aa}(p)$ to the maximally consistent proposition of P_{aa} that is entailed by p. This is the aspect that "filters out" all information that is not about the particles aa. Add α_{aa} to the system of aspects.

[10] Here, I am using the notion of entailment in Bacon and Dorr (2024). Namely, $\leq := \lambda pq.q = p \vee q$.

3. Repeat this process for all the other collections of particles that the nihilist singles out. The resulting system should be $\mathcal{A}_{\mathrm{N}}$.

The universalist might build $\mathcal{A}_{\mathrm{U}}$ in a similar way, but using singular terms instead of plural terms. The claim that the nihilist and the universalist are talking about the same portions of reality can then be understood as the claim that $\mathcal{A}_{\mathrm{N}}$ and $\mathcal{A}_{\mathrm{U}}$ are identical, or perhaps the weaker claim that they are coextensive. This doesn't require the nihilist and the universalist to have the same singular terms or plural terms in their language, or to agree on the "correct" object-property analyses of the aspects they single out.

There are, however, some subtleties. For example, the inflationist might ask why the nihilist is allowed to use plural terms in the construction of $\mathcal{A}_{\mathrm{N}}$ when the universalist might not. In some accounts (e.g., Uzquiano 2004), if the universalist also uses plural terms then her system can express propositions that the nihilist cannot. If that is the case, $\mathcal{A}_{\mathrm{N}}$ and $\mathcal{A}_{\mathrm{U}}$ might not be identical or coextensive. The deflationist might retort that this is not a problem: both sides have set-theoretic vocabulary and might also be able to talk about sets of simples or composites, or even sets of sets thereof, which would allow the nihilist to articulate the universalist's talk by moving up one or more levels in the (transfinite) set hierarchy. But more complications follow. For instance, the inflationist might object that the universalist and the nihilist sometimes disagree on what possibilities are even available: as Sider (1993) has argued, some worlds the universalist considers possible are impossible for the nihilist. Such disagreements might also imply that $\mathcal{A}_{\mathrm{N}}$ and $\mathcal{A}_{\mathrm{U}}$ are neither identical nor coextensive.

Nonetheless, my goal here is not to defend the thesis that the nihilist and the universalist *are indeed* talking about the same portions of reality. Rather, I want to show that we can make sense of the deflationist's claim in a way that is neutral to object-property analyses. The details of how the nihilist and the universalist construct their systems of aspects is up for grabs. The claim might apply to some idealized versions of the nihilist and the universalist, or might simply not apply to this case at all, and yet we can still make sense of this claim, and of the deflationist's talk about "portions of reality". This talk might, in turn, be useful characterizing other debates (as I try to show in §4), or might be of independent interest (as I try to show in §2.5).

2.5 Developing the Aspect Framework

So far, I have advanced the aspect framework as a way to make sense of the deflationist's talk about "portions of reality" in a way that is neutral to object-property analyses. But once we have this framework in place, we can also use it to articulate other metaphysical notions which might be of independent interest.

For instance, we can define a notion of *parthood* among aspects. We often imagine that one portion of reality sits inside another (like a table's leg is part of the table). Accordingly, if an aspect α' is a "part" of α, then any proposition specifying something *about* α' should *thereby* also specify at least as much *about* α. This is captured by the following definition, where $\leq$ is the entailment relation:

Parthood. α' is a *part* of α ($\alpha' \sqsubset \alpha$) iff for all propositions p, $\alpha(p) \leq \alpha'(p)$.

$$\sqsubset := \lambda\alpha\alpha'.\forall p(\alpha(p) \leq \alpha'(p))$$

One can also use an aspect α to define a notion of *equivalence* for propositions and of aspect-relativized *entailment* ($\leq$) and *strict entailment* ($<$).[11] In turn, we might use these notions to define a relativized notion of *necessity* and *possibility*:

Equivalence and Entailment. Given an aspect α and propositions p and q, we say that:

- p is *α-equivalent* to q ($p \equiv_\alpha q$) iff $\alpha(p) = \alpha(q)$. $\quad \equiv_\alpha := \lambda pq.\alpha(p) = \alpha(q)$
- p *α-entails* q ($p \leq_\alpha q$) iff $\alpha(p)$ entails $\alpha(q)$. $\quad \leq_\alpha := \lambda pq.\alpha(p) \leq \alpha(q)$
- p *strictly α-entails* q ($p <_\alpha q$) iff $\alpha(p)$ strictly entails $\alpha(q)$. $\quad <_\alpha := \lambda pq.\alpha(p) < \alpha(q)$

Relative Modality. Given an aspect α, a proposition p is *α-necessary* iff it is α-entailed by the tautology $\top$, and *α-possible* iff it is strictly α-entailed by the contradiction $\bot$.

$$\Box_\alpha := \lambda p.\top \leq_\alpha p \qquad\qquad \Diamond_\alpha := \lambda p.\bot <_\alpha p$$

One should understand $\ulcorner\Box_\alpha p\urcorner$ as saying that p doesn't impose any constraints on the aspect α. Thus, in a sense $\ulcorner\Box_\alpha p\urcorner$ is true iff p "doesn't say anything" about α—or, rather, if it only imposes *trivially satisfiable* constraints on α. Similarly, $\ulcorner\Diamond_\alpha p\urcorner$ can be read as saying that p doesn't pose *unsatisfiable* constraints on α.

One can further develop aspect-talk by quantifying over aspects to capture whether a proposition talks about a *wider* or *narrower* range of reality than another, and if it talks about it in a *finer* or *coarser* way. This requires fixing a given system of aspects $\mathcal{A}$ and reading '$\exists\alpha$' as type-($t \to t$) quantification over the aspects which comprise $\mathcal{A}$.

Coverage. p *covers* q ($p \leq_C q$) iff for every aspect q says something about, p says at least as much.

$$\leq_C := \lambda pq.\forall\alpha(p \leq_\alpha q)$$

[11] Entailment should be understood along the lines of footnote 10. Strict entailment should be understood thus: $< := \lambda pq.p \leq q \wedge \neg(q \leq p)$.

Extension. p is a *strict extension* of q ($p <_E q$) iff p covers q and p says something about at least one aspect q says nothing about.

$$\leq_E := \lambda pq.p \leq_C q \wedge \exists\alpha(p <_\alpha q \wedge \Box_\alpha q)$$

Refinement. p is a *strict refinement* of q ($p <_R q$) iff p covers q and p says strictly more about at least one aspect q already addresses.

$$\leq_R := \lambda pq.p \leq_C q \wedge \exists\alpha(p <_\alpha q \wedge \neg\Box_\alpha q)$$

In each of these definitions, the crucial idea is that we look at how p and q behave under all aspects α in a system. If we interpret a given system $\mathcal{A}$ as *the portions of reality*, then these definitions give us a way to talk about how propositions can be related to one another in terms of the portions of reality they address. For instance, it is plausible that [The ball is red] is strictly extended by [The ball is red and the cube is blue], while being strictly refined by [The ball is red and made of rubber].

3 Philosophy of Physics: Structuralism and Subsystems

We have seen how the aspect formalism can be used to articulate the deflationist's notion of "portions of reality" and thereby clarify the claim that nihilists and universalists are, in fact, talking about the same portions of reality, despite employing different object-property analysis of these portions. We have also seen that this formalism remains neutral with respect to which analysis of objects and properties a speaker adopts. It turns out that this formalism also provides a way to defend the thesis that physics itself is neutral about the relevant object-property analyses of its subsystems. This view has been advocated in the context of structural realism (Ladyman and Ross, 2007; Wallace, 2022b), though the usual line of argument often urges us to *reject* metaphysics as an intellectual endeavour. By contrast, the defense I will sketch suggests is that we can maintain such a neutrality thesis without rejecting metaphysics: indeed, the logical tools used to express aspect-based neutrality (in particular, higher-order logic) are precisely those that contemporary (meta)metaphysics employs.

The key step is to recognize that physical subsystems in Wallace's sense—that is, elements of what he calls *subsystem-structures*—can be interpreted as portions of reality in the manner developed in the previous sections. Once each physical theory is viewed as describing a collection of subsystems, and once we identify each subsystem with a corresponding aspect, the neutrality toward competing object-property analyses follows naturally. In other words, we can regard each subsystem as an aspect of facts that physics "talks about" without taking a stance on whether this aspect should ultimately be read as a single object, a plurality, or some other thing.

Even though Wallace himself defends similar neutrality theses regarding physics (Wallace, 2022b), his development of the subsystem framework is not motivated by this thesis. Instead, the motivation was to argue against the interpretative assumptions that physical theories are primarily understood as (i) *exactly* modelling the deepest features of reality, and (ii) as describing *the entire universe* at once. Wallace (2022a) argues that these assumptions are not only unnecessary but also lead to difficulties in philosophy of physics. Instead, he suggests an interpretative framework according to which physical theories should be understood as describing *subsystems* of the universe, which is supposed to be general enough to apply to a wide range of physical theories.

Surprisingly, this independently motivated framework can be used alongside the aspect formalism—another independently motivated framework—to defend the thesis that physics is neutral with respect to object-property analyses of the subsystems it describes. In what follows, I will provide a very brief overview of the key concepts, mainly to fix the notation and terminology. The reader is encouraged to consult Wallace (2022b) for a more detailed treatment of the formalism with examples drawn from physical theories. I will then show in §4 how this framework can be given an *aspect interpretation*, providing a new way to understand the neutrality thesis in the context of structural realism.

3.1 Wallace's Subsystem Structures

Wallace's framework is based on the notions of *subsystem-structures*, *state-structures*, and *symmetry groups*. The first of these concepts is the most basic one, and it is defined as follows:

> ***Subsystem-structure***. A *subsystem-structure* is a set $\mathcal{X}$ equipped with a partial order $\prec$, along with a minimal subsystem $0_{\mathcal{X}}$ and a maximal one (also denoted $\mathcal{X}$, slightly abusing notation).

Here, we should think of $\mathcal{X}$ as a set of subsystems, and of each subsystem as corresponding to a "part" of physical reality, something that will be made precise in §4. The subsystem relation $\prec$ captures the idea that one subsystem can be embedded in another. Along these lines, two subsystems X and Y are *disjoint* if any subsystem Z such that $Z \prec X$ and $Z \prec Y$ is equal to $0_{\mathcal{X}}$.

Aside from the subsystem structure itself, each subsystem is equipped with a *state space* and a set of *restriction maps* that determine how the state of a larger system is related to the state of a smaller one. This is captured by the notion of a *state structure*:

> ***State-structure***. Given a subsystem structure $\mathcal{X}$, a *state structure* for $\mathcal{X}$ is specified by:
>
> 1. An assignment S of a *state space* $S(X)$ (a set of possible states) to each subsystem $X \in \mathcal{X}$, such that $S(0_{\mathcal{X}}) = \varnothing$.

2. An assignment r of a *restriction map* $r_{XY} : S(Y) \to S(X)$ to each pair $\langle X, Y\rangle$ of systems with $X \prec Y$. These maps satisfy the following conditions:

   (i) $r_{XX} = \mathrm{id}_{S(X)}$, the identity map on $S(X)$.

   (ii) If $X \prec Y \prec Z$, then $r_{XZ} = r_{XY} \circ r_{YZ}$.

   (iii) If $X \prec Y$, then r_{XY} is surjective.

   These conditions ensure that if $X \prec Y$ and $y \in S(Y)$, we can unambiguously write $y|_X$ for $r_{XY}(y)$.

As a specific case, Wallace discusses the case of N*-particle theories*, in which a subsystem is a tuple $X = \langle K, I\rangle$, where K is a subset of $\{1, \ldots, N\} \subseteq \mathbb{N}$ (representing the particles to be included in the subsystem) and I is a subset of $\mathbb{R}$ (representing the period of time for which X describes the particles). Given $X_1 = \langle K_1, I_1\rangle$ and $X_2 = \langle K_2, I_2\rangle$, we set $X_1 \prec X_2$ iff $K_1 \subseteq K_2$ and $I_1 \subseteq I_2$. That is, $X_1 \prec X_2$ iff X_2 describes all the particles X_1 does and describes them for all the times X_1 does. The state space $S(X)$ of $X = \langle K, I\rangle$ is the set of smooth maps from $K \times I$ to $\mathbb{R}^3$. For each map $x : K \times I \to \mathbb{R}^3$ of $S(X)$, one should think of $x(n,t)$ as representing the location of particle n at time t. Along these lines, the *restriction maps* $r_{XY} : S(Y) \to S(X)$ for two subsystems $X = \langle K_1, I_1\rangle$ and $Y = \langle K_2, I_2\rangle$ with $X \prec Y$ should simply be the *functional* restrictions $y \in S(Y) \mapsto y|_{K_1 \times I_1} \in S(X)$ applied to these smooth maps.

As a more concrete example, consider the case of $N = 3$. The *maximal* subsystem would be $\mathcal{X} = \langle\{1,2,3\}, \mathbb{R}\rangle$, and the *minimal* subsystem would be $0_{\mathcal{X}} = \langle\varnothing, \varnothing\rangle$. A *state* of $\mathcal{X}$ would be a smooth map $x : \{1,2,3\} \times \mathbb{R} \to \mathbb{R}^3$, where, for instance, $x(1,0) \in \mathbb{R}^3$ would represent the location of particle 1 at time $t = 0$. We can also consider the functional restriction $r_{Y\mathcal{X}}$ where $Y = \langle\{1,2\}, \mathbb{R}\rangle$ is a strictly smaller subsystem of $\mathcal{X}$. Here, $r_{Y\mathcal{X}}$ would be the functional restriction of x to the subset $\{1,2\} \times \mathbb{R}$, so $x|_Y := r_{Y\mathcal{X}}(x)$ would be the function $y : \{1,2\} \times \mathbb{R} \to \mathbb{R}^3$ such that $y(n,t) := x(n,t)$ for $n \in \{1,2\}$ and $t \in \mathbb{R}$, which would represent the location of particles 1 and 2 at each time $t \in \mathbb{R}$ (Figure 1).

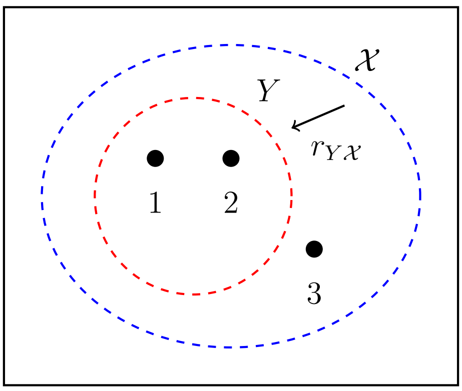

Figure 1: Subsystems $\mathcal{X}$ and Y in a 3-particle theory.

Aside from this structure, particle theories and other theories have *symmetries*: transformations between states of subsystems that leave certain physical properties invariant. Presented abstractly, symmetries can be characterized in terms of *symmetry groups*:

Symmetry group. A *symmetry group* $\mathcal{G}$ for a subsystem structure $\mathcal{X}$ (with a given state structure) consists of:

1. An assignment $\mathcal{G}$ of a group $\mathcal{G}(X)$ to each subsystem $X \in \mathcal{X}$.
2. An assignment τ of a group homomorphism $\tau_{XY} : \mathcal{G}_X(Y) \to \mathcal{G}(X)$ to each pair $\langle X, Y \rangle$ of systems with $X \prec Y$, where $\mathcal{G}_X(Y)$ is a subgroup of $\mathcal{G}(Y)$. The assignment τ satisfies the following conditions:
   (i) $\tau_{XX} = \mathrm{id}_{\mathcal{G}(X)}$, the identity map on $\mathcal{G}(X)$.
   (ii) If $X \prec Y \prec Z$, then $\tau_{XZ} = \tau_{XY} \circ \tau_{YZ}$ whenever $\tau_{XY} \circ \tau_{YZ}$ is defined.
   (iii) Each τ_{XY} is surjective.

   These conditions ensure that if $X \prec Y$ and $g \in \mathcal{G}(Y)$, then we can write $g|_X$ for $\tau_{XY}(g)$.

Each symmetry $g \in \mathcal{G}(X)$ should be thought as *acting* on the subsystem X in a certain way, something which can be captured by the group-theoretic concept of an *action*:

Action. The *action* of a symmetry group $\mathcal{G}$ on a subsystem structure $\mathcal{X}$ is an assignment of group actions[12] $R_X : \mathcal{G}(X) \to (S(X) \to S(X))$ to each subsystem $X \in \mathcal{X}$, such that for all $X \prec Y$ and $g \in \mathcal{G}_X(Y)$, $(R_X \circ \tau_{XY}(g)) \circ r_{XY} = r_{XY} \circ (R_Y(g))$ or, equivalently, in more compact notation,

$$(g|_X)(y|_X) = (gy)|_X \text{ , for all } y \in S(Y).$$

In the case of N-particle theories, Wallace considers *spacetime symmetries* and *permutation symmetries*, which are respectively characterized by transformations of the following two forms:

$$(gx)(n,t) = F_t(x(n, f(t))) \text{ , and}$$
$$(gx)(n,t) = x(\sigma(n), t)$$

where $\{F_t \mid t \in \mathbb{R}\}$ is a family of bijections of $\mathbb{R}^3$, f is a bijection of $\mathbb{R}$ and σ is a permutation on $\{1, \ldots, N\}$. Here, the specific functions F_t, f depend on the particular theory being considered. Given any $X = \langle K, I \rangle$, the symmetry group $\mathcal{G}(X)$ is the set of all of these transformations g :

[12]A *group action* of a group $(G, \cdot)$ on a set A is a function $R : G \to (A \to A)$ such that $R(g \cdot h) = R(g) \circ R(h)$ for all $g, h \in G$. We often write ga for $R(g)(a)$ when it is implicitly clear what the action is.

$S(X) \to S(X)$ closed under composition, with the action being simply the application of these transformations to the smooth maps in $S(X)$.

In interpreting this formal structure, Wallace suggests states related by a symmetry should be thought of as differing only *extrinsically*—i.e. only in how they are related to other subsystems. Given this interpretative assumption, he defines the following notions of discernibility:

Discernibility. For any two states $x, x' \in S(X)$ of a subsystem X, we say that:

- x' is *intrinsically discernible* from x if there is no $g \in \mathcal{G}(X)$ with $x' = gx$, in other words, if no internal symmetry identifies them.
- x' is *extrinsically discernible* from x if it is not intrinsically discernible, and there are Y and $y \in S(Y)$, such that for any Z with $X, Y \prec Z$ and any two states $z, z' \in Z$ with $z|_X = x$, $z'|_X = x'$, and $z|_Y = z'|_Y = y$, z and z' are intrinsically discernible. In this case, we say that y is a *witness* to the extrinsic discernibility of x and x'.
- x' and x are *indiscernible* if they are neither intrinsically nor extrinsically discernible.

In the next subsection, I propose a way to interpret these structures via the aspects framework introduced previously. This yields an interpretation of physics that remains neutral on specific object-property analyses of subsystems and physical facts about them.

4 Subsystems as Aspects

Having introduced both aspects (§2) and subsystem structures (§3), I now propose a way to bridge these two frameworks. The goal is to show how Wallace's subsystem formalism can be interpreted in terms of my aspect formalism.

Aspect interpretation. Let $\mathcal{X}$ be a subsystem structure (with its corresponding state structure). An *aspect interpretation* for $\mathcal{X}$ is a mapping such that:

1. *Aspect Assignment.* Each subsystem $X \in \mathcal{X}$ is assigned an aspect α_X, such that for all $X \prec Y$, we have $\alpha_X \sqsubset \alpha_Y$. This ensures that "smaller" subsystems correspond to "smaller" aspects in the partial order of aspects.
2. *Proposition Assignment.* Each pair $\langle X, A\rangle$, where $A \subseteq S(X)$, is assigned a proposition $p_{\langle X,A\rangle}$ such that the following conditions hold:
   (i) For all p, $\alpha_X(p) = p$ if and only if $p = p_{\langle X,A\rangle}$ for some $A \subseteq S(X)$.
   (ii) If $A \subseteq B \subseteq S(X)$, then $p_{\langle X,A\rangle} \leq p_{\langle X,B\rangle}$. Also, $\Diamond_{\alpha_X} p_{\langle X,A\rangle}$ if $A \neq \varnothing$.

(iii) For $X \prec Y$ and any $B \subseteq S(Y)$, define $B|_X = \{\, y|_X : y \in B \}$. Then we require

$$p_{\langle X,\, B|_X \rangle} \;=\; \alpha_X \big(p_{\langle Y,\, B \rangle} \big).$$

We should think of an aspect interpretation as assigning each subsystem X the aspect or portion of reality α_X that corresponds to X, with the "embedding" relation $\prec$ corresponding to the "part" relation $\sqsubset$. The proposition $p_{\langle X,A \rangle}$ is then *that X is in one of the states in A*. These propositions should comprise the range of α_X, a condition that (i) ensures. The assignment should also be monotonous, as per condition (ii).

Condition (iii) captures the idea that if X is a subsystem of Y, then the proposition that X is in one of the states in $B|_X$ is exactly what you get by filtering the proposition that Y is in one of the states in B through α_X. Thus, *restrictions* $r_{XY} : S(Y) \to S(X)$ in Wallace's framework correspond to applications of α_X to some proposition $\alpha_Y(p)$. Hence, the condition that r_{XX} is the identity map corresponds to the condition that $\alpha_X \circ \alpha_X = \alpha_X$, which is guaranteed by the Identity axiom on aspects. Relatedly, if we have $X \prec Y \prec Z$, then the condition that $r_{XZ} = r_{XY} \circ r_{YZ}$ corresponds to the condition that $\alpha_X \circ \alpha_Z = \alpha_X \circ \alpha_Y \circ \alpha_Z$, which obtains because $\alpha_X \sqsubset \alpha_Y \sqsubset \alpha_Z$. Lastly, the surjectivity condition corresponds to the condition that if $X \prec Y$, then for every p with $\alpha_X(p) = p$, we have a q with $\alpha_Y(q) = q$ such that $\alpha_X(q) = p$. This obtains because $\alpha_X \sqsubset \alpha_Y$.

In sum, we can produce a mapping from each subsystem structure $\mathcal{X}$ to a *system of aspects* $\mathcal{A}_{\mathcal{X}}$, where each subsystem X corresponds to an aspect α_X of $\mathcal{A}_{\mathcal{X}}$, and each pair $\langle X, A \rangle$ with $A \subseteq S(X)$ corresponds to a proposition $p_{\langle X,A \rangle}$ in α_X's range. Of course, this mapping is not unique, and subsystem structures can be variously interpreted, but the important point is that each of these interpretations is *aspectual* in nature, and thus neutral with respect to the object-property analysis of these subsystems. This provides a new way to understand the neutrality thesis in the context of structural realism. But more than that, it also suggests that the deflationist's "portions of reality" can *themselves* be understood as subsystems, providing a new way to understand the deflationist-inflationist debate from the point of view of philosophy of physics.

4.1 Symmetries and Intrinsic Interpretations

Wallace (2022a) suggests that symmetries should be interpreted as preserving the *intrinsic* properties of a subsystem and only changing its *extrinsic* properties—i.e., its relations to other subsystems. The current framework has the resources to capture this interpretative constraint. We begin by defining the notion of a *state specification*—a proposition that exactly specifies the state of a subsystem:

State specification. Given a subsystem $X \in \mathcal{X}$, a proposition q is a *state specification* for X iff there is a state $x \in S(X)$ such that $q = p_{\langle X, \{x\} \rangle}$.

It turns out that there is a condition that only state specifications of X satisfy, and which can be expressed without explicitly talking about states: p is a state specification for X iff

$$\Diamond_{\alpha_X} p \wedge (\alpha_X(p) = p) \wedge \forall q(\Diamond_{\alpha_X} q \wedge (\alpha_X(q) = q) \to (p \leq q)).$$

Just as we identify states via symmetries in Wallace's framework, we can "identify" state specifications via these same symmetries. This is captured by the following definition:

Symmetry mapping. Given a subsystem $X \in \mathcal{X}$ and a symmetry $g \in \mathcal{G}(X)$, and two state specifications q and q' for X, we say that q *maps to* q' *under* g (written $q \mapsto_g q'$) iff there is a state $x \in S(X)$ such that $q = p_{\langle X, \{x\}\rangle}$, $q' = p_{\langle X, \{gx\}\rangle}$.

Note that this defines a relation $\mapsto_g$ of type $t \to (t \to t)$ between propositions. We can then use this relation to define the notion of *symmetry equivalence*:

Symmetry equivalence. Given a subsystem $X \in \mathcal{X}$, we say that two state specifications p and p' for X are *symmetry equivalent* (written $p \sim_{\mathcal{G}(X)} p'$) iff there is a symmetry $g \in \mathcal{G}(X)$ such that $p \mapsto_g p'$.

Given that groups have inverses and identities, $\sim_{\mathcal{G}(X)}$ is an equivalence relation. We then use this relation to define, for any subsystem X, an aspect α_X° which is concerned only with how X is when one ignores any differences between symmetry-related states. Assuming Wallace's interpretative stance, this should correspond to ignoring any *non-intrinsic* differences between states of X. This is captured by the following definition:

Intrinsic aspect. Given a subsystem X, the *intrinsic aspect* α_X° of X is the unique subaspect of α_X such that

(i) for all state specifications p, p' for X with $p \sim_{\mathcal{G}(X)} p'$, we have $\alpha_X^\circ(p) = \alpha_X^\circ(p')$; and

(ii) for any $\alpha \sqsubset \alpha_X$ satisfying (i), we have $\alpha \sqsubset \alpha_X^\circ$.

Now, we have the resources to define the notion of *discernibility* in terms of aspects.

Aspect discernibility. Given a subsystem $X \in \mathcal{X}$, we say that two state specifications p and p' for X are:

- *intrinsically discernible* ($p \, \Delta_X^i \, p'$) iff $\alpha_X^\circ(p) \neq \alpha_X^\circ(p')$;

- *extrinsically discernible* ($p \, \Delta^e_X \, p'$) iff $\neg(p \, \Delta^i_X \, p')$ and there is a subsystem Y and a state specification p_Y for Y such that for any Z with $X, Y \prec Z$ and any state specifications p_Z and p'_Z for Z with $\alpha_X(p_Z) = p$, $\alpha_X(p'_Z) = p'$, and $\alpha_Y(p_Z) = \alpha_Y(p'_Z) = p_Y$, we have $p_Z \, \Delta^i_Z \, p'_Z$.
- *indiscernible* iff neither $p \, \Delta^i_X \, p'$ nor $p \, \Delta^e_X \, p'$.

Given Wallace's interpretative constraint, we should consider indiscernible states as being *mere gauge*—that is, as states that "do not differ in any physically-relevant way and yet are mathematically represented as distinct" (Wallace, 2022a, p. 245). Since the propositions assigned to these states contain only the *physical content* of the theories that describe the subsystem structure, adopting this interpretative stance amounts to saying that indiscernible state specifications are *identical*. That is, it amounts to accepting the following constraint:

Gauge. For all $X \in \mathcal{X}$ and all state specifications p, p' for X, we have

$$(p \, \Delta^i_X \, p') \vee (p \, \Delta^e_X \, p') \vee (p = p').$$

So far, we have seen how the aspect formalism can be used to interpret Wallace's subsystem structures. This interpretation provides a way for proponents of the "ontological neutrality" of physics to articulate their thesis that physical theories are neutral with respect to object-property analyses of the subsystems they describe. In the rest of this section, I will provide a rough sketch of how aspect interpretations can be used to defend this thesis in the context of a specific problem in the metaphysics of physics.

4.2 Three- vs. High-Dimensional Ontologies in Quantum Mechanics

When it comes to the metaphysics of quantum mechanics, a question that is often discussed in the context of the Bohmian interpretation is whether the ontology of the theory should be understood in terms of a *three-dimensional* space or a *high-dimensional* configuration space. Call proponents of the former view *three-dimensionalists* (or 3D-ists) and proponents of the latter view *high-dimensionalists* (or HD-ists). Both the 3D-ist and the HD-ist are *Bohmian* in that they think that the quantum state of the universe is *definite* or *pure* at all times, and that the universe consists of particles being moved around by a wave function. The difference between them is in how they understand the *space* in which these particles move, with the 3D-ist positing *many* particles in a *three-dimensional* space (Maudlin, 2019), and the HD-ist positing *one* "marvelous particle" in a *high-dimensional* space (Albert, 2015).

More precisely, when presented with the same surface-level picture of the universe (the "manifest image") with N particles moving around in a three-dimensional space, the 3D-ist will take it at face value by positing, at each time t, N vectors $\mathbf{x}_1, \ldots, \mathbf{x}_N$ in $\mathbb{R}^3$ representing the positions of the particles and a square-integrable function $\psi : (\mathbb{R}^3)^N \to \mathbb{C}$ representing the state of the wavefunction. The HD-ist, on the other hand, will take the same surface-level picture and posit a single vector $\mathbf{X}$ in a high-dimensional space $\mathbb{R}^{3N}$ representing the positions of all the (surface-level) particles at once, and a square-integrable function $\Psi : \mathbb{R}^{3N} \to \mathbb{C}$ representing the state of the wavefunction. The HD-ist has the advantage that the wavefunction can be understood as a *field* "living" in the same space in which the marvelous particle moves, while the 3D-ist has the advantage of having a picture that is closer to the manifest image.

It is a simple mathematical fact that the two models are isomorphic via the canonical isomorphism $F : (\mathbb{R}^3)^N \to \mathbb{R}^{3N}$ that takes N vectors $\mathbf{x}_1, \ldots, \mathbf{x}_N$ to a single vector $\mathbf{X} = (\mathbf{x}_1, \ldots, \mathbf{x}_N)$, and its inverse $G : \mathbb{R}^{3N} \to (\mathbb{R}^3)^N$ that takes a single vector $\mathbf{X}$ to N vectors $\mathbf{x}_1, \ldots, \mathbf{x}_N$. Of course, everyone working on the Bohm interpretation knows this, and most don't take the fact that this isomorphism exists as pointing that the 3D and High-D formulations impose the same conditions on the world. For one, the 3D formulation needs there to be a large number N of particles, while the High-D needs there to be exactly one. Thus, if we have a preexistent notion of particle which we can use to interpret the predicate 'P', only one of the formulations makes the following statement true when we quantify over its relevant (object-level) ontology:

(P) $\exists x \forall y (Py \leftrightarrow y = x)$.
There is exactly one particle.

But here we can also be deflationists like we were in the nihilist vs. universalist debate. Only that in this case it's *easier*: in the nihilist vs. universalist debate, we need to commit that both are using "there is" and/or "part" differently. These are words that we use all the time, and the context relative to which we would use them are everyday contexts: contexts where we find are confronted with objects like tables, chairs etc (or the corresponding particle-arrangements). On the other hand, it is harder to defend that words like "particle" aren't theory dependent in physics, or that "there is" isn't to be read against the background of a theory when one does physics. Thus, the deflationist about this debate would have an easier time defending that the following are to be read as *the same claim* under two different interpretations $[\![\ldots]\!]_{\text{3D}}$ (3D-ist) and $[\![\ldots]\!]_{\text{HD}}$ (HD-ist):

(3D) Particle n is at position **a** at time t. $[\![\mathbf{x}_n(t) = \mathbf{a}]\!]_{\text{3D}}$

(HD) The n-projection of marvelous particle's position at time t is **a**. $[\![\pi_n(\mathbf{X}(t)) = \mathbf{a}]\!]_{\text{HD}}$

where the n-projection is the function $\pi_n : \mathbb{R}^{3N} \to \mathbb{R}^3$ such that $\pi_n(x_1, \ldots, x_N) = \langle x_{3n-2}, x_{3n-1}, x_{3n} \rangle$, for each $n \in \{1, \ldots, N\}$.

At this point, many will jump off the boat and say that the 3D and HD formulations are simply *not* the same, and when the 3D-ist and HD-ist are disagreeing on whether to describe the manifest image using (3D) or (HD), they are both *really* disagreeing about how the world is. That would mean, in turn, that (3D) and (HD) really express different propositions. If this is advanced as a brute claim, then the deflationist has no option other than to advance her own brute claim, and the debate will be at a standstill.

But the inflationist can also advance her claim by noting that, even if the 3D-ist and the HD-ist can be read as having *informationally equivalent* theories (as in Maudlin 2007), they are *not ontologically equivalent* theories, for only the 3D-ist can be read as making claims *about* the (3D) particles, and only the HD-ist can be read as making claims *about* the (HD) marvelous particle. This is where the aspect formalism comes in: one can think about a 3D particle as a particular *aspect of facts* which is rendered salient in the 3D theory by letting 't' and '$\mathbf{a}$' vary in the schema $[\![\mathbf{x}_n(t) = \mathbf{a}]\!]_{3\mathrm{D}}$—just as SOCRATES is an aspect which is rendered salient in (A). Conditional on the deflationist claim that the 3D and HD theories are informationally equivalent being true, it follows that the HD theorist is in the position to capture *the same aspect* by letting 't' and '$\mathbf{a}$' vary in the schema $[\![\pi_n(\mathbf{X}(t)) = \mathbf{a}]\!]_{\mathrm{HD}}$. Thus, the deflationist can argue that the 3D-ist and the HD-ist are both *really* talking about the aspects of facts which correspond to the 3D-ist's *particles*. Analogously, the 3D-ist is also *really* capturing the aspect of facts corresponding to the HD-ist's marvelous particle by letting 't' and '$\mathbf{a}_1, \ldots, \mathbf{a}_N$' vary in the schema $[\![\mathbf{x}_1(t) = \mathbf{a}_1 \wedge \cdots \wedge \mathbf{x}_N(t) = \mathbf{a}_N]\!]_{3\mathrm{D}}$.

The deflationist might add that whether we render these aspects salient by using singular terms (e.g. "the particle n") or by a more complicated linguistic structure is a matter of *presentation*, not of *substance*. The difference lies in the network of connections that we use, and not the facts being described, or on the "metaphysical character" of the aspects of these facts that are rendered salient via these descriptions.

Of course, this is a very rough sketch of the deflationist stance on this debate. A complete defense of the position would require showing that these two theories also produce the same systems of aspects when taken to describe subsystems of the universe. This could be done, for example, by interpreting the 3D-ist's theory along the lines of Wallace's subsystem structrure for N-particle theories, and producing an analogous interpretation for the HD-ist's theory. Then, we might use the deflationist's claim that (3D) and (HD) are informationally equivalent to argue that the two interpretations produce the same system of aspects. I leave this as a task for future research.

5 Conclusion

Both Wallace's subsystem-recursive framework and the aspects formalism were designed to address talk about *local facts*: facts about certain "portions of reality" that are not meant to describe the entire universe at once. The aspects framework was developed to address metaphysical disputes about whether “tables” exist or whether there are “only” particles arranged tablewise, while Wallace’s framework was developed to address interpretative issues in philosophy of physics. The surprising result of this paper is that these two frameworks can be seen as two sides of the same coin: the aspects framework can be used to interpret Wallace’s subsystem structures, and aspects themselves exhibit a subsystem structure.

What the subsystem-aspect analogy shows is that subsystems can be seen as *aspects* of reality as conceived above. This correspondence supports the thesis that the physical treatment of subsystems can remain *neutral*, in the sense that it doesn’t force a specific object-property analysis of subsystems and facts about them. Thus, it provides a new way to understand the neutrality thesis in the context of structural realism, and in turn suggests that the deflationist’s talk about “portions of reality” can be understood as talk about physical subsystems.

Arguments for the object-property neutrality of physics have been previously defended in Ladyman and Ross (2007) and Wallace (2022b), and the current paper can be seen as advancing yet another argument for this thesis. What distinguishes this approach from more familiar defenses of neutrality is that it originates from a formalism already used in metaontological debates about objects and properties. In that sense, it “comes from within” metaphysics, and shows how philosophers can adopt the structuralist stances advocated by Ladyman or Wallace without discarding the conceptual tools of traditional metaphysics. Rather than rejecting metaphysics outright, the present approach suggests that we can use tools from (meta)metaphysics to clarify and defend theses in philosophy of physics, and how the insights we gain in doing so may in turn be useful for clarifying positions in metaontology.

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