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Fragmenting the Wave Function

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A key insight of Fine (2005)'s *fragmentalism* is that there is a symmetric coordination relation between facts, such that facts that are pairwise incompatible (like Hugh's being happy and Hugh's being sad) can both obtain provided that they are not related by this relation.[1] Here, I will use the term 'fragmentalism' to describe any view that incorporates this insight. In this paper, I will present a new fragmentalist account of B-theoretic endurantism and a new fragmentalist account of the metaphysics of the quantum state, and I will highlight the deep parallels between the considerations that motivate them. Along the way, I will make clear that these new accounts do not rely on the further details of Fine's (or Lipman's) fragmentalism — e.g. on the claim that reality is (logically) incoherent, in the sense that P can obtain in one fragment while $\neg P$ obtains in another.

The new fragmentalist account of B-theoretic endurantism is motivated by a strengthened version of Sider (2001)'s problem of exotica, which I present below. The new fragmentalist account of the quantum state, which I will call *conservative realism* about the quantum state, is motivated by the desire to reconcile three desiderata: first, (com-

[1] Fine (2005) calls this relation *coherence* and Lipman (2015) calls it *co-obtaining*. I follow Lipman in assessing the key insight of Fine's view. Following both authors, I stress that talk of facts may be regarded as loose speaking, shorthand for talk that can be couched in terms of sentential operators.

pleteness) that the universal quantum state says (more or less) all there is to say about the universe, second, (anti-holism) that the universal quantum state is grounded in its branches, and third, (familiarity) that the branches are grounded in local states of affairs involving the positions of particles in space-time. Most abandon at least one of these desiderata. As we will see, there is a striking parallel between the strengthened version of the problem of exotica, and the considerations that have led most to abandon one of these three desiderata for the quantum state.

I will proceed as follows. In §1 I distinguish between three strategies for B-theoretic endurantists: relativizing, outsourcing, and defusing, and I motivate fragmentalism as the most promising development of the defusing strategy. In §2 I consider two cases, the cases of *spooky isolation* and *spooky coincidence*, which grow out of Sider (2001)'s argument from exotica against endurantism, and I argue that no other endurantist theory can handle these cases as well as fragmentalist endurantism. In §3 I present the considerations that seem to force the rejection of conservative realism, highlight the striking parallel between these considerations and the *spooky* arguments against endurantism that I consider in §2, and then present the fragmentalist implementation of conservative realism. Along the way, I will make it clear that fragmentalism need not be "jagged" (i.e., facilitate contradiction) in order to underwrite either fragmentalist B-theoretic endurantism or conservative realism about the quantum state.

1 Strategies for B-Theoretic Endurantists: Relativizing, Outsourcing and Defusing

I take a B-theoretic endurantist view to be a view according to which one and the same entity can instantiate both of a pair of apparently incompatible properties (like the property of being happy and the property of being sad, or the property of being red and the property of being green, or the property of being round and the property of being square), and do so by being wholly present "twice over": once at each instantiation – or anyway *not* by having temporal parts or counterparts. [2] Here I will distinguish three strains of B-theoretic endurantism that fit this description, strains that differ over how they make sense of the idea that one and the same thing can have apparently incompatible properties at different times: relativizing accounts, outsourcing accounts and defusing accounts. We will see that fragmentalism yields a cogent defusing account.

1.1 Relativizing Accounts

According to relativizing accounts, the endurant directly instantiates two properties that are apparently incompatible, but there is no real incompatibility, because the properties that the endurant instantiates, or the episode of instantiation itself, constitutively involve further variables: there is some parameter of persistence — presumably, time — and to be happy or sad is really to be suitably related to one or another value of this parameter.

There are important debates among relativizers: Mellor (1981) and Van Inwagen

[2] My aim here is not to offer an all-encompassing characterization of endurantism *per se*. I am not concerned with what endurantism requires at worlds where things do not change their properties as they persist. And there are views that are neither stage-theoretic nor worm-theoretic, but which may not qualify as endurantism in my sense (e.g. Nolan 2014). Also, my characterization allows a B-theoretic endurantist to countenance enduring perdurants — things that have multiple temporally extended locations, which others will resist. For more on the general characterization of endurantism see Donnelly (2011), Effingham (2012), Gilmore (2014), and Parsons (2007).

(1990) say that even apparently intrinsic properties, if they are temporary, must really be relations to times. Johnston (1987) and Lowe (1988) hold that there can be truly intrinsic temporary properties but in instantiating them we are related to times. Similarly Haslanger (1989) says that propositions which report on the instantiation of temporary intrinsics are true relative to times.[3] I note that the challenges I will consider below do not hinge on questions about intrinsics.

1.2 Outsourcing Accounts

According to outsourcing accounts, the endurant does not *directly* instantiate both of the pair of incompatible properties. On such accounts there are two genuinely incompatible properties and they are directly instantiated by distinct individuals, at least one of which is not the endurant, though the endurant *takes the credit*. On such accounts either it is strictly true that the endurant instantiates the properties, though it does so indirectly, i.e., by proxy, or it is not strictly true but we nevertheless have pragmatic reasons to talk as though it is true.

Standard worm-theoretic perdurantist accounts involve outsourcing: the worm takes the credit for the properties instantiated by its temporal parts. But endurantist outsourcers say that the thing that takes the credit is wholly located at the proxies that do the instantiating. Outsourcing accounts call for an ontology that takes in more than endurants (or they bottom out in relativizing or defusing accounts).

For example, Eagle (2010) defends an outsourcing account in which an endurant e counts as having property P at region r insofar as e is exactly located at region r and region r has property P. Giordani and Costa (2013) and Costa (forthcoming) defend a rival outsourcing account in which for an endurant e to have property P at time t is for

[3]A sophisticated recent variation is Spencer (2016). Parsons (2007)'s distributional property approach is a borderline case. Neither of these views fare any better than standard relativizing approaches against the challenges I raise below.

there to be some event in which e participates in some suitable way, which is located at t and instantiates P.[4]

1.3 Defusing Accounts

According to defusing accounts, the endurant directly instantiates two properties *simpliciter* that are genuinely incompatible, but there is a mitigating factor which somehow *defuses* this incompatibility.[5] A successful defusing account must provide an analysis of property incompatibility that explains how it can be defused (i.e., explain what incompatibility is, such that one and the same thing can instantiate (*simpliciter*) a pair of incompatible properties if defused), and it must also provide an analysis of defusing, one which makes it neither too rare nor too ubiquitous.

There are three questions that confront a defuser. The first is how to understand the relevant kind of property incompatibility. On one extreme, the relevant kind of property incompatibility is logical incompatibility. This route leads to dialethism. On the other extreme, we restrict our attention exclusively to pairs of properties that are not really incompatible (like *Thinking about Tennis* and *Thinking about Golf*). But then we cannot account for change between genuine incompatibles. A middle ground focuses on non-logical but genuine incompatibilities, such as that of *Happy* and *Sad*.

The second question is how to identify the conditions that do the defusing. Plausibly, this is a role played by time. But as we will see below, other conditions may serve as well.

The third is to identify the mechanism of defusing. If the defusing strategy is to

[4]See Miller (2013) for critique and Costa and Giordani (2016) for reply. Another outsourcing theory says that endurants are haecceities instantiated by perdurants. See Benovsky (2011).

[5]Here I take it that in having a property *simpliciter*, there is no *mode* with which one has it, and nothing to which one's having it is a relation (my usage corresponds with that of Lewis 2001). In the sense I have in mind, relativizers must deny that endurants have ordinary properties *simpliciter*. Compare Miller (2005) and Miller and Braddon-Mitchell (2007).

be an alternative to relativizing or outsourcing strategies, it is not enough to say that Harry can be both happy *simpliciter* and also sad *simpliciter* provided that he is happy at one time and sad at another. What *is it* for Harry to be happy at one time and sad at another, if it is not what relativizers or outsourcers say it is?

At the time of writing I am aware of no authors who endorse non-fragmentalist defusing strategies explicitly. Authors that come close to adopting the defusing strategy, but who do not quite do so, include Ehring (1997), Mellor (1998), and Hansson (2007).[6] Ehring, Mellor and Hansson all reify property instances (as tropes, in Ehring's case, and facts in Mellor and Hansson's). All three also suppose that property instances can have temporal locations, and deny that it follows that the property in question *is* a relation to a temporal location (*contra* Kim 1983, Chisolm 1976, and others). However, none of these authors accept that it follows from the existence or obtaining of the property instance of Hugh's being happy that 'Hugh is happy' is true *simpliciter*, at least not if the 'is' in question is the B-theoretic, fundamentally untensed 'is-*simpliciter*'.[7] All three are therefore relativizers in my broad sense. But these authors, at least, embrace ontologies hospitable to the defusing strategy.

As I will explain just below, fragmentalism emerges as a compelling implementation of the defusing strategy. But any workable defusing approach has an advantage over relativizing and outsourcing accounts. Any such account would permit us to infer from 'x is F at t' that 'x is F' is true *simpliciter* in the fullest possible sense, where nothing is

[6]Honorable mention goes to Carroll (2011), who suggests that the endurantist's best response to time travel cases like the spooky coicidence case I discuss below is to accept that properties like sitting and standing are compatible after all. Carroll does not address the more general question of what makes it true that, e.g., the apple is red at t_1 but brown at t_2. If Carroll were to seek to answer this question (without invoking a relativist or outsourcing account after all) his answer would likely lead to a defusing account.

[7]Hansson (2007) comes closer than Ehring or Mellor to a defusing strategy. He holds that the fact that Hugh is happy makes 'Hugh is happy' true, where the 'is' is understood as tenseless. But in his (2007) he states and in his (2010) he clarifies that the tenseless copula he has in mind can be elucidated in terms of a disjunction of tensed copulae; roughly: 'was, presently-is, or will be', and he denies that the fact that Hugh is happy makes 'Hugh is happy' true if the 'is' is a strict *simpliciter* copula. (see especially his (2010 §VII) and his (2013: 243)).

relativized and nothing is outsourced. To those influenced by Lewis (1986)'s argument from temporary intrinsics this is virtue enough.[8]

1.4 Fragmentalism

Defusers must identify both the conditions under which incompatibility is defused and the mechanism of defusing. In the "Mellorian" analysis, the condition is time: two properties are incompatible just in case nothing can instantiate them at the same time. And to make sense of "instantiation at a time" one countenances property instances (like Hugh's being happy) and then takes these to themselves have temporal-locational properties.

But time is obviously parochial here: a more ecumenical analysis would speak generally of whatever parameters of persistence may vary at the world in question or of whatever kinds of locations the relevant states of affairs can have. In those terms we might say: what it is for two properties P and Q to be incompatible is for it to be impossible for there to be any x such that the state of affairs Px and the state of affairs Qx share a location.

The fragmentalist goes a step further. Instead of thinking of states of affairs as having locational properties or standing in locational relations, the fragmentalist introduces a primitive relation, *co-obtaining* (terminology creditable to Lipman 2015), which can relate states of affairs without relating them spatiotemporally. As we will soon see, it is this feature which allows fragmentalism to solve problems which other endurantist theories (including other defusing theories) cannot solve.

I stress (following Fine and Lipman) that for those who eschew an ontology of relations between facts, the structure we wish to capture here may be expressed with sentential operators. Following Lipman we may use '$\circ$' as a binary sentential operator

[8]But see Eddon (2010) for reasons to doubt the argument from temporary intrinsics.

expressing co-obtainment, readable as 'insofar as': '$Fa \circ Gb$' says that a is F *insofar as* b is G.[9] But for ease of exposition I will continue to quantify over facts.

A fragment is then a maximal collection of states of affairs that mutually co-obtain. Something can instantiate incompatible properties provided that the instantiations do not co-obtain, and what it is for two properties P and Q to be incompatible is for it to be impossible for anything to be P insofar as it is Q.

We generally suppose that when two properties are incompatible it is impossible that they be co-instantiated *simpliciter*. Fragmentalists (and defusers more generally) must qualify this claim. But there is a choice point here – a question of how much incompatibility the fragmentalist thinks we can live with, or in other words, a question of how "jagged" one's fragmentalism is.

Broadly there are three grades to consider. What we might call *dialethic fragmentalism* revises our logic itself, allowing for true (first-order) logical contradictions to obtain without *quodlibet*. Loss (2017) endorses such a view.

What we might call *jagged fragmentalism* allows that fragments may fail to cohere with one another, in the sense that there is some notion of obtaining-in-a-fragment such that P can obtain in one fragment while $\neg P$ obtains in another, but this does not engender genuine contradiction. Both Fine (2005,2006) and Lipman (2015a,b,2016) endorse versions of jagged fragmentalism, though they implement it in different ways.[10]

What I will call *smooth fragmentalism*, in contrast, denies that there is any genuine incoherence, within the relevant operators or without. On this approach, logic

[9]Lipman (2015b). Note that temporal defusers also need a *primitive* notion of location for states of affairs. Hansson (2007 §6) points out that perdurantists, insofar as they countenance states of affairs, must also take these to have locations. However the perdurantist can treat a state of affairs' location as derivative on the location of the particular entity (the perdurant) that participates in it.

[10]Fine takes the logic of predication to involve an *In Reality* operator, such that it does not follow from 'In Reality $\neg P$' that '$\neg$ In Reality P', but such that contradictions would ensue if this inference could be drawn. Lipman allows that some (non-atomic) facts may co-obtain without obtaining *simpliciter*. Hugh's not being happy co-obtains with Hugh's being sad, but if Hugh's being happy also obtains (in a distinct fragment) then Hugh's not being happy does not obtain.

remains classical, reality is coherent, and obtaining is a pre-condition for co-obtaining with something or other. On this approach, we do not claim to defuse any logical inconsistency in any guise. Instead we focus exclusively on those cases of metaphysical incompatibility that do not generate logical incompatibility — ie, distinct determinates of a common determinable, like being scarlet (all over) and being crimson (all over). I tentatively endorse this view, though here, my focus will be on motivations for the fragmentalist framework broadly construed.[11]

Distinct versions of fragmentalism face distinct challenges. The smooth fragmentalist faces a semantic challenge: we ordinarily talk as though 'sad' implies 'not happy'. Suppose that Hugh is happy in one fragment and sad in another. Dialethic fragmentalists may allow that the fact that Hugh is not happy obtains, while jagged fragmentalists may allow that it obtains-in-a-fragment. But the smooth fragmentalist denies this. The smooth fragmentalist appeals to pragmatics: in relevant circumstances, 'Hugh is not happy', though literally false (because it *means* that the fact that Hugh is not happy obtains), *conveys* that Hugh's being happy is not a part of the relevant fragment.[12]

There are some challenges faced by both smooth fragmentalists as well as jagged fragmentalists (like Lipman) who distinguish between facts that obtain and those that merely co-obtain. For example, shape properties like 'round' and 'square' or 'straight' and 'bent' may seem like basic, positive properties, but on closer inspection there are reasons to suspect otherwise. Arguably, part of what it is to be round is to *not* have

[11]Tractarian accounts seek to reduce all cases of metaphysical incompatibility to cases of logical incompatibility. See again Moss (2012), Turner (forthcoming) for recent defenses. If the Tractarian can show that *Scarlet* and *Crimson* really are logically incompatible, this is a problem for the smooth fragmentalist. But fragmentalism can be a boon for the Tractarian who concedes that there is no logical incompatibility here, because fragmentalism allows us to deny that *Scarlet* and *Crimson* are incompatible with metaphysical necessity. Of course the fragmentalist holds that it is impossible that their instantiations *co-obtain*, but further resources are available here. The logic of co-obtainment may shed light on the logic of determinable relations. Moreover, in some cases anyway the fragmentalist might hold that incompatibilities are nomological rather than metaphysical.

[12]For example, if we treat 'At-t' as a sentential operator, such that 'At-t P' is true iff the fact that P obtains and is located at the t-situation, then we might say that 'Hugh is not happy' uttered at t generally communicates that ¬At-t (Hugh is happy), though it *means* that At-t (¬Hugh is happy).

any right angles in one's boundary, and part of what it is to be square is for there to *not* be any central point such that all of one's boundary points are equidistant from it, on any relevant metric. But then these fragmentalists cannot allow that something that changes from being round to being square is both round *simpliciter* and also square *simpliciter*. Which is it? Similar problems arise with mereological predicates like 'overlap' and locative ones like 'exact location'.[13]

But these limitations also help to illustrate why smoother forms of fragmentalism do not go too far. Just as pain is your body's way of telling you that it needs fixing, so inconsistency is a theory's way of telling you that it needs fixing. A worry about dialethic fragmentalism, and perhaps some jagged fragmentalisms, is that they foster one with an all-purpose pain-killer, a way of living with something that needs fixing, rather than taking measures to repair it. But smooth fragmentalism requires that there is no inconsistency or incoherence between any fact that obtains in a fragment and any other fact that obtains in any other fragment. Thus, for example, the smooth fragmentalist cannot resolve the paradox of the statue and the clay by affirming the identity of the two while maintaining that the statue can survive shattering in one fragment but not in another (but see Pickup 2016). Thus the applicability of smooth fragmentalism, anyway, must be evaluated on a case by case basis, by considering its implications for what facts would end up obtaining *simpliciter*.

Now, for some applications, it matters which version of fragmentalism we embrace. On Fine's approach each fragment's pronouncements about what is past and what is future are inconsistent with one another, and on Lipman's approach real change

[13]The beginning of a reply: a shape specification can be separated into a positive and a negative component. The positive component specifies the parts a thing has or the points or regions it occupies (and the metric and topological connections among these); the negative component states that the thing has no more parts, or occupies no further points or regions, beyond these. The negative components get the same treatment as 'Hugh is not happy'. An alternative is to deny the relevant implications, for example by taking the relevant properties or ideology as primitive, though it would be a weakness of the view if this were compulsory.

requires passage from one thing's being the case to its negation being the case. But the considerations I present below motivate smooth fragmentalism as well as its more rough-hewn cousins.

What is the logic of the co-obtainment relation? This depends on the version of fragmentalism one prefers. All should agree that it is symmetric: the relation is not order-sensitive. Reflexivity is trickier: if it is true *simpliciter* that Hugh is happy, but also true *simpliciter* that Hugh is sad, then if co-obtainment is transitive we must deny that the conjunction of these facts co-obtains with itself. On the other hand there are advantages to denying transitivity. If co-obtainment is not transitive, we can think of one and the same state of affairs as involved in different fragments. Suppose there is one fragment in which Caspar is happy and hungry, and another in which he is happy and sated. If the fact that Caspar is happy is identical in both cases then by transitivity Caspar's being hungry would co-obtain with his being sated.[14] Note also that co-obtainment is not the same as compresence: x's being F may co-obtain with y's being G.

How does fragmentalism accommodate ordinary cases of change? It depends on how things and states of affairs turn out to be located at the world in question. I will develop this theme at greater length below. But assuming there are times, and objects are located at them, what it is for Hugh to be happy at t_1 is for the state of affairs of Hugh's being happy to co-obtain with the state of affairs of Hugh's being temporally located at t_1. More generally, if this is a classical Newtonian world at which time travel is impossible, a single fragment might comprise all of the goings on at t_1. If Hugh is happy and Donald is sad at t_1, then Hugh's being happy and Donald's being sad and Hugh's being at t_1 and Donald's being at t_1 all co-obtain.

Fragmentalism gets more interesting as the worlds in which we want to accommo-

[14]Both Mellor (1998) and Fine (2005) duplicate states of affairs. Ehring (1997) similarly duplicates tropes, but that is arguably a more familiar move.

date endurance get more interesting. Insofar as we are concerned only with classical Newtonian worlds (and we are comfortable quantifying over times) fragmentalism and a temporal defusing strategy more or less coincide. But fragmentalism shines when we confront scenarios that do not offer up other entities obviously suited to serve as parameters of persistence. I turn my attention now to some of these.

2 Spooky Isolation and Spooky Coincidence

Sider (2001 4.7)'s argument from exotica targets the same aspect of endurantism as the argument from temporary intrinsics: viz., the endurantist's need to index property instantiation to a parameter of persistence. But where the argument from temporary intrinsics identifies a special difficulty with this, one that only arises if the relevantly indexed properties are intrinsic, the argument from exotica identifies a general difficulty, one which arises no matter what the arity of the properties involved: namely, that it can vary from world to world what parameters of persistence there are but it should not vary from world to world what it is to instantiate the relevant properties.

Sider's argument centers around two cases, the case of timeless worlds and the case of time-travelling worlds. At timeless worlds, Sider argues, endurantists must deny that being round (for example) is a relation to a time (or a temporal mode of instantiating roundness). This suggests an uncomfortable duality: how can there be two species of roundness, or two modes of instantiation of roundness?

At time travel worlds, Sider argues, endurantists must take it that there is some further parameter of persistence in addition to time. That step may be anyways motivated in a relativistic world, but it seems to lack any independent motivation in the non-relativistic case. Others have more recently noted that time travel carries other costs for the endurantist: for example it suggests a tension with the axioms of minimal

mereology.[15]

These arguments are important, but as I will discuss, endurantist replies are available. However, we can add details that make the cases far more difficult for the endurantist to respond. The only version of endurantism that can comfortably respond to these modified cases is fragmentalist endurantism (and there are no further modifications that make it difficult for the fragmentalist to respond). Incidentally, these modifications of the argument from exotica make for an argument that is strikingly similar to an argument against conservative realism about the quantum state. As we will see in the next section it is therefore no accident that fragmentalism offers a novel response to that argument as well.

2.1 Spooky Isolation

Endurantists can bite the bullet and allow that there are two ways of being round: the temporal way which we employ at our world, or the atemporal way employed at a timeless world. As Sider points out, some endurantists who also countenance perdurants, but deny that either grounds the other, may have to accept that there are two distinct ways of being round anyway.

Endurantists can also insist that even at timeless worlds there is some parameter or other to which properties may be indexed. Endurantists may say that what is necessary is that properties are indexed to locations, while what is contingent is that the indices at our world are times. Thus, a relativizer may say that I am round-at t, while my counterpart is round-at l, where l is some suitable location at the timeless world. The outsourcer may take the endurant's proxies to be located at locations like l, and a non-fragmentalist defuser might hold that two states of affairs are incompatible only

[15]See for discussion Donnelly (2010), Gilmore (2006), (2009), (2014), Effingham (2007, 2010), and Kleinschmidt (2011).

if it is impossible that they have the same location.

But all of this is only as compelling as the claim that a timeless world must involve locations (or distance relations). What if we stipulate, against the endurantist, that the problem case is a timeless world in which there are no distance relations? Maybe the endurantist can insist that the only possibility in the vicinity is a world where there is only one token location (or equivalently, a world where everything is zero distance from everything else). But even this is no help if we stipulate that one and the same thing instantiates both of a pair of (apparently) incompatible properties at such a world.

Of course the endurantist may refuse to countenance such an outlandish possibility. But if the endurantist countenances non-empty location-free worlds at all, the endurantist has some reason to countenance such a world where a thing instantiates incompatibles.

If we allow, as B-theoretic endurantists do, that something can have multiple whole locations at a world, we have some reason to embrace an at-a-location haecceitistic permutation principle, which holds we can permute haecceities whole location by whole location rather than endurant by endurant. If we allow that things can have properties at location-free worlds we need a more general notion than "whole location" — call them *manifestations*. But if we make it this far, we should say that the permutation principle extends to all manifestations. Now consider a location-free world where Caspar is happy and Homer is sad. Then by the permutation we obtain a world where Caspar is happy and Caspar is sad. Call this the case of *spooky isolation*.

But the spooky isolation case does not contain enough things for standard endurantists to differentiate the two manifestations of Caspar. Either both manifestations share a single location or there are no locations at all for them to share.[16] In contrast, the

[16]Non-fragmentalist defusers (who appeal to difference in location rather than co-obtainment structure) may say that the relevant states of affairs lack locations, which means they do not share a location, which defuses the incompatibility. However, this strategy entails that no states of affairs may be coordinated with one another at such a world. Maybe Caspar can be happy and feel pleasure

fragmentalist can allow that a spooky isolation case is coherent as described, simply by maintaining that Caspar's being happy and Caspar's being sad are not part of the same fragment: that is, that Caspar's being happy does not co-obtain with Caspar's being sad.[17]

This counts in fragmentalism's favor, at least insofar as we have reason to countenance the permutation principle noted above. But I do not raise this case because it is decisive, I raise it because it foreshadows what is to come. As we will see just below, the case of spooky coincidence is better motivated, and it leads to an analogous challenge for endurantism. Moreover, as we will see shortly thereafter, there is a striking parallel between this case and standard cases of quantum superposition which lead to a challenge for conservative realism about the quantum state.

2.2 Spooky Coincidence

As with the problem of timeless worlds, there are various ways that endurantists can respond to the problem of time travel as Sider presents it. As above, properties may be taken to be relations to locations, where the exact nature of the locational relata varies from world to world. Modes of instantiation might also correspond to types of locations generally rather than times in particular. The outsourcer is fine as long as there is a category of proxies to appeal to, and the non-fragmental defuser is fine as long as incompatible states of affairs must not share a location.[18]

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at one manifestation while being sad and feeling pain at another. The non-fragmental defuser cannot differentiate this scenario from one at which Caspar is happy and feels pain at one manifestation and is sad and feels pleasure at another. We might describe the former scenario thus: $|Happy\rangle_c |Pleasure\rangle_c + |Sad\rangle_c |Pain\rangle_c$, and describe the latter thus: $|Happy\rangle_c |Pain\rangle_c + |Sad\rangle_c |Pleasure\rangle_c$.)

[17] And unlike the non-fragmental defuser I discuss in the previous note, the fragmentalist can with equal comfort differentiate between the $|Happy\rangle_c |Pleasure\rangle_c + |Sad\rangle_c |Pain\rangle_c$ scenario and the $|Happy\rangle_c |Pain\rangle_c + |Sad\rangle_c |Pleasure\rangle_c$ scenario by differentiating their co-obtainment structure.

[18] This is to suppose that the real problem for the endurantist is having to add a second parameter to the index, not the problem of breaking down the disanalogy between space and time (on which see Miller (2006) or the problem of possibilities that the endurantist cannot differentiate (on which see Simon 2005).

Sider notes that matters are more difficult if the time travelers lack spatial locations.[19] If the time travelers lack spatial locations the time travel case behaves much like the case of spooky isolation — at least if we also specify that these aspatial beings do not occupy "non-spatial" locations or stand in some "non-spatial" distance relation that can serve as a parameter of persistence or change.

But we can achieve the same troubling effect even in worlds where all beings have spatiotemporal locations, provided that some of these beings are capable of both time travel and interpenetration. These are the kinds of cases that I will call *spooky coincidence* cases.

At one such world Caspar is happy in his youth but melancholy as time passes. He travels back in time and passes right through his younger self (coincidentally he has kept his figure!), but this does not allay his sorrows: his journey to the past is a mournful one. Thus there is an exact region of space-time at which Caspar is wholly present twice over: happy on the first pass and sad on the second.[20]

The case of spooky coincidence raises the same difficulty for endurantists as the case of spooky isolation. It is a further challenge, even for endurantists who embrace the need to index property instantiation to place as well as time or to spatiotemporal region, because in this case there is a pair of a place and a time, or a spatiotemporal region, such that Caspar is happy at it and also sad at it. The case is equally a problem for outsourcers, because it suggests that they must find two distinct proxies that share a spatiotemporal location. And it is a problem for non-fragmentalist defusers who say states of affairs are incompatible if they cannot share a location, because by the lights of that strategy, spooky coincidence cases involve incompatible states of affairs sharing a location.

[19] Sider (2001 p.105).

[20] This example traces back at least to Gilmore (2004: 190). Hawthorne discussed it at in a commentary on Sider at the 2006 Pacific APA. It is also discussed in Carroll (2011).

As with the case of spooky isolation, we can deny the possibility of this case. We can deny the possibility of time-travelling ghosts outright, for example. Alternatively we can deny that Caspar has two coincident manifestations. But what, then, is Caspar feeling at the moment of apparent self-interpenetration: is he happy or sad, or both? Proposals holding that it is one or the other seem arbitrary: does he experience a fleeting spark of joy in his haunted old age, or a somber spell of sorrow in his spirited youth? And we have maintained that by 'happy' and 'sad' we mean to denote properties that are genuinely incompatible.[21]

So it looks as though, unless they are willing to go further and deny the possibility of all things that can travel back in time and pass through their former selves, endurantists have some reason to countenance the possibility of spooky coincidence cases. In disanalogy with the spooky isolation case, I have not stipulated any restrictions on what else there is at the world in question. The endurantist therefore has the option of countenancing the case by appealing to further basic ontology (or ideology), for example a dimension of hyperspace,[22] or a *sui generis* dimension of personal time.[23] But ought we really expand our metaphysics just to handle cases like this? And shouldn't we be able to say that if such cases are possible they are possible in worlds with no hyperspace and only one temporal dimension?[24]

It might seem that the only cases at issue are nomologically impossible anyway. But here is an argument that there might be a spooky coincidence case even at a wholly

[21]A possible reply: mental properties are a special case. We can make sense of one and the same thing instantiating 'incompatible' mental properties insofar as that thing's conscious experience is not *unified* (see Bayne and Chalmers 2003 for discussion). So perhaps the answer is that at the moment of self-interpenetration Caspar's consciousness momentarily becomes disunified. However some (including Bayne and Chalmers 2003) argue that a subject's conscious experience is necessarily unified at a time, on which more below.

[22]Hudson (2005), Lockwood (2005).

[23]See Gilmore (2016) and Valaris and Matthew (2015). Note that many give reductive accounts of personal time. But if personal time is reducible it is hard to see how Caspar might have his different mental states in relation to different values of it (cf. Sider (2001: ch. 4.7))

[24]See Kleinschmidt (2010: ch. 4) for a discussion of alternative strategies for the endurantist that avoid appealing to personal time. None are cost free.

material, ghost-free world. Consider a commisurotomy (split-brain) patient living at the nearest possible world to ours which is both non-orientable and contains closed time-like curves: i.e., such that there are subluminal trajectories that leave one in the "past" and "mirror reversed" (but note that neither notion is globally defined at such a world). Say also that in such a commisurotomy case there are two subjects: one, L, whose cognition centers on the left hemisphere and the other, R, whose cognition centers on the right hemisphere. But each subject extends beyond the center of its core cognition, just as you or I do. Suppose in particular that L and R mereologically and spatio-temporally coincide: a supposition to which an interpenetration-friendly endurantist should be open. Now at t_1 surgeons perform an operation: they remove L and replace it with NL, an alternative left hemisphere that houses a subject. After the surgery NL relates to R in the same way that L did before the surgery: each is a distinct center of consciousness: NL sees only the word 'able' where R sees only the word 'tax', etc. Much later, at t_100, NL and R are separated. R is taken along a path that leaves it mirror reversed in the surgery room at (t_0) and hey presto, it turns out that R = NL — or anyway, it does assuming an endurantist account of persistence. We then have a case of spooky (though not ghostly) coincidence in the time between the two surgeries, that is, between t_1 and t_100.[25]

As with the spooky isolation case, the spooky coincidence case is a challenge for all endurantists. Unless extra ontology is introduced, relativizers have nothing to relativize to, outsourcers have nothing to outsource to, and temporal defusers have

[25]This case relies on the rejection of the various 'single mind' interpretations of split-brain cases (see again Bayne and Chalmers 2003). This is controversial: many (including Bayne and Chalmers) defend such interpretations. But there is much to be said for a 'two minds' approach (or more generally a 'not exactly one mind' approach: Nagel (1971) suggests that the number of minds is *fractional*). It coheres with the phenomenal unity thesis without making us hostage to the existence of asymmetries accounting for which hemisphere dictates conscious experience at any given moment. The implication that two minds can (perfectly) coincide might be anathema to some, but recall that our challenge is aimed at endurantists, and many endurantists accept at least some cases of perfect coincidence (see for discussion Gilmore 2014).

nothing to defuse with: both states of affairs have the same spatiotemporal location.[26] But introducing extra ontology is problematic in its own right. Does this extra ontology (e.g. *sui generis* personal time) only exist at worlds where there actually are cases of spooky coincidence, or must it also exist at worlds where there *could be* such cases? If the latter, then the endurantist position may force us to actually countenance that extra ontology, since as I note above versions of the case may be possible at worlds relevantly like ours.

The fragmentalist, in contrast, can allow that a spooky coincidence case is coherent as described insofar as Caspar's being happy and Caspar's being sad are not part of the same fragment, or in other words, insofar as Caspar's being happy does not co-obtain with Caspar's being sad.[27]

Of course in the spooky coincidence case there is more to say about what makes up a fragment. This points to another incidental virtue of fragmentalism: the fragmentalist is not compelled to identify a single parameter of persistence *even at a world*. At a spooky coincidence world, other things equal, fragments in which no one is doing any time travel may correspond to goings on at times or spatiotemporal regions. It is only in the special case of Caspar's coincidence that we have two 'co-located' fragments. These will each comprise all of the other goings on at the relevant region, and one or the other of Caspar's mood state-of-affairs, but not both. But it does not follow that every property instantiation must be located at the pair of a region and a mood.

Fragmentalism therefore offers the endurantist a very comfortable response to the problems of exotica, a response that accommodates even the most extremely exotic

[26]Sider (2001: 4.8) notes one "desperate reply": to relativize property coinstantiations to one another. This makes property instantiation more holistic than some will find palatable, but more generally, what does it add to say that being happy is a relation to not being sad?

[27]Gilmore (personal communication) raises a challenge. Presumably it is true that young Caspar is happier than old Caspar. But if young Caspar and old Caspar do not share a fragment, where can this fact obtain? One solution, noted above, is to deny the reflexitivity of co-obtainment. We may then deny that this fact co-obtains with any other fact. Alternatively, we may think of it as inhabiting a fragment of its own, a fragment which is a counterexample to the transitivity of co-obtainment.

versions of these problems with no extra ontological or ideological accumulation.[28] I conclude that even B-theoretic endurantists have good reason to consider fragmentalism.

I turn my attention now to another selling point of fragmentalism: it provides us with a novel analysis of the metaphysics of the non-relativistic quantum state, one that may appeal to perdurantists or endurantists alike. Along the way we will observe the striking analogy between the arguments from exotica that I have just considered and the argument against the theory of the wave function that I am about to develop. And I reiterate that nothing here turns on the dialethic or jagged facets of some versions of fragmentalism: even smooth fragmentalism can foster the novel analysis promised here.

[28] A caveat: I have not addressed here the special mereological questions that time travel raises for endurantism. It might seem that the fragmentalist is bound to say that parthood is really a two-place relation, a relation that does not involve locations or times. The fragmentalist may say this, but need not. The fragmentalist may alternatively follow, e.g. Gilmore (2009) in holding the fundamental parthood relation to be four-place, relating a whole, the whole's region, the part, and the part's region. The relevant state of affairs would co-obtain both with the whole being located at the whole's region and the part being located at the part's region.

3 Spooky Action at a Distance

Measurements of the spin of an electron along a given axis — say, the z-axis — will result in observations of one of two values: 'up' ('↑') or 'down' ('↓'). However if the electron has not very recently been polarized along the z-axis, then the quantum state of its spin will not be one of these values or the other: it will be a non-trivial superposition of both, describable in Ket notation, with c_1 and c_2 standing for non-zero complex numbers, as:

(1) $c_1 |\uparrow\rangle + c_2 |\downarrow\rangle$

Philosophers dispute the metaphysical nature of the quantum state. If quantum mechanics were our final theory, what should we understand an expression like (1) to be telling us about the world?

The expression mentions two simple states that an electron might be in. These states are apparently, in some sense, incompatible. But on a flat-footed reading, incompatibility aside, the equation seems to be telling us that both states obtain (and also that there is a parameter, amplitude, designated by a complex number, that somehow modifies the way that they obtain). Indeed, the equation is a quantum analogue of the spooky isolation scenario considered above.

According to this flat-footed reading, what the equation tells us is that the electron is in both of these states, and its being in the state of having up-spin along the z-axis has amplitude c_1 while its being in the state of having down-spin along the z-axis has amplitude c_2 (the reading is neutral on what it is for a state of affairs to have amplitude c, but more on this below. It is at minimum clear that values of amplitude cannot serve as parameters of persistence or locations for the states of affairs, since c_1 may equal

c_2).

Why be dissatisfied with the flat-footed reading? Well, for one thing, up-spin along the z-axis and down-spin along the z-axis are incompatible, or anyway, they are at least as incompatible as being happy *simpliciter* and being sad *simpliciter*. For another thing, quantum states can become *entangled*. For example, in general if a spin-zero particle decays into a pair of two electrons, those electrons (call them a and b) are in the singlet state:

(2) $\frac{1}{\sqrt{2}}(|\uparrow_a\downarrow_b\rangle - |\downarrow_a\uparrow_b\rangle)$

It is less obvious what a flat-footed reading of (2) would say. It had better at least say that a has up-spin and b has down-spin and also that a has down-spin and b has up-spin. But the singlet state tells us more: in particular, it tells us that somehow the first two states of affairs are coordinated as are the latter two (in such a way that any measurement of the system is bound to yield either the first coupling or the second). In other words, it tells us that it is not the case that a and b have the same spin-state (along the z-axis). So even if we abandoned our scruples about the co-instantiation of incompatible properties to allow that an isolated electron can have both up-spin and down-spin along the z-axis, this is not enough to make sense of entanglement. If we allow for the instantiation of incompatibles we can say that a has both up-spin and down-spin, and so does b. But this is not enough to accommodate the further facts of coordination: that is, the facts about entanglement as such.

For this and closely related reasons, many authors conclude that the quantum state must be, in one sense or other, holistic: we must take equations like (1) and (2) to be describing properties of the system that cannot be metaphysically explained in terms of properties of the system's components — at least not in any ordinary sense

of *component*. Indeed this is sometimes presented as a direct consequence of the fact that quantum states like the one described in (2) are *non-separable*, i.e. entangled.[29]

But the fragmentalist can say otherwise. Setting the question of amplitude temporarily aside, the fragmentalist can countenance the face value reading of (1): the state of affairs of the electron's having up-spin along the z-axis obtains, and so does the state of affairs of that same electron's having down-spin along the z-axis: but these two states of affairs do not co-obtain, and indeed, as they are incompatible, they cannot co-obtain. With the same tools the fragmentalist can accommodate (2): it tells us that a has up-spin *insofar as* b has down-spin, and also that a has down-spin *insofar as* b has up-spin. That is, the first and second states of affairs co-obtain, as do the third and fourth, but neither the first nor the second co-obtains with the third or the fourth: we have two distinct fragments.

In other words, fragmentalism offers a precise answer to a vexing question, one that many take to afford only imprecise answers: what is a quantum mechanical 'branch'? The fragmentalist answer is that a branch is a fragment. But where standard theories of branches take them to be derivative of the quantum state as a whole, characterized primarily as terms in equations like (2), the fragmentalist may take branches to be built up out of states of affairs involving the things that equations like (2) purport, on the flat-footed reading, to be talking about. I call this view *conservative realism* about the quantum state ('conservative' in the sense that it conserves our intuitive conception of what things and properties are fundamental, 'realist' in that it shares with quantum state realism the idea that the quantum state is (more or less) all there is).

Conservative realism combines the key element of primitive ontology approaches, namely that the fundamental or primitive ontology contains local 'beables': observable entities that instantiate more or less familiar properties and can be localized in space

[29]See for discussion Ismael and Schaffer (2016), Darby (2012), Calosi (2013), Esfeld (2014), Teller (1986).

or space-time — with the key element of no-primitive-ontology approaches, namely that there is no more (or anyway not much more) to reality than what is comprised by the quantum state.[30]

At the same time, conservative realism is flexible concerning the answers to the big interpretive questions. There can be conservative realist collapse theories and conservative realist no-collapse theories, since this is ultimately just a question of the dynamics of amplitude across branches. And speaking of amplitude, the conservative realist has options concerning what it is: it might be a primitive property of fragments or a primitive relation between them, or we can give it some kind of analysis – e.g., we can think of its modulus squared, following Vaidman (1998) as standing in for a *measure of existence* of situations, or following Sebens (2015) as standing in for a measure of the density of copies of a given situation.[31]

There is also no default conservative realist story about survival, or how to individuate branches over time. The conservative realist may appeal to various accounts currently on offer.[32] But fragmentalism, as we have seen, also offers a framework for endurantist theories. And this suggests new possibilities. In particular it suggests novel ways for a theory of survival in a quantum mechanical world to accommodate further facts about identity over time, should one want to do so. For example, one possibility is to think of the macroscopic entities at each branch as counterparts of one another, but nevertheless take the macroscopic entities at each branch to survive

[30]Conservative realism compares to Sebens (2015)'s Newtonian Quantum Mechanics. But conservative realism is not committed to an interpretation of amplitude as branch-density, and more importantly, conservative realism offers a metaphysical alternative to the two that Sebens (2015, sec. 11) considers: that worlds are points in a high dimensional configuration space whose structure is grounded in their dynamics, and that worlds are *parameters* instantiated by particles (or, perhaps, that serve as parameters relative to which particles instantiate properties). But one could develop Newtonian QM within a conservative realist (i.e. fragmentalist) framework.

[31]This would require that we follow Mellor (1998) and Fine (2005) in allowing duplicates of one and the same state of affairs, moreover here we cannot take these duplicates to have different spatiotemporal locations.

[32]See for example Albert (2015), Wallace (2011).

into future branches (e.g. a unique one for each time). Paths of macroscopic survival might then be determined by the flow of amplitude. This could allow the conservative realist to deploy a frequentist account of the Born rule, just as the Bohmian may.[33] Another option is to think of branches are fundamentally static, and think of the only real changes as changes in the distribution of amplitude.[34]

The conservative realist theory compares to other theories of quantum reality that take the notion of a branch, or world, to be primitive (rather than derived from the decoherence structure of the wave function).[35] But difficult questions arise for such theories. What exactly are branches and what differentiates them? Here, we confront parallels of questions that arise in the endurance/perdurance debate. Can one and the same thing exist on more than one branch? If so, do we relativize the having of properties to branches? The fragmentalist approach offers us the same elegant solution here that it offers to the analogous questions about time: it allows us to account for branching structure, just as it allows us to account for temporal structure, without having to deny that things can exist at more than one branch (time), and also without having to relativize (or outsource) the having of properties to branches (times). Moreover, on the fragmentalist account branches still *are* derivative entities: it is just that they are grounded in individual facts and their co-obtainment relations, rather than the quantum state as a whole.

Of course there are challenges for the conservative realist approach. How if at all does it generalize to the relativistic case? And since it denies that branch structure

[33]If this is just to say that the fragmentalist *may* add additional structure, why cannot others do the same? The answer is that the conservative realist's branches are suited to accommodate this sort of additional structure in ways that branches that derive from the quantum state as a whole are not.

[34]This account would in some respects resemble that in Albert (2015). The world consists of a multitude comprising a branch for every way that things might be, and the dynamics of the universe is given entirely by the specification of how amplitude redistributes (along hydrodynamic lines, but without a world-density analysis). On this view the facts about 'persistence lines' are all derivative of the hydrodynamics.

[35]See again Sebens (2015).

emerges out of (the dynamics of) the quantum state, mustn't it posit further structure beyond that contained within the quantum state after all?

It would require more than a few paragraphs to address these issues in the depth they merit.[36] But my aims here are relatively modest. I do not seek to show here that the conservative realist approach to quantum mechanics is superior to its rivals in all matters. My aim has been to show that the theory offers a novel alternative, one which allows us to continue thinking of more-or-less familiar, non-holistic facts about the location of particles as fundamental, without adding primitive ontology beyond the wave function.

4 Conclusion

I hope to have highlighted the interest and utility of the fragmentalist framework, beyond its role in the analysis of A-theoretic tense, passage, and related phenomena. To this end I have argued that it yields a novel account of B-theoretic endurance, and also a novel account of the metaphysics of the quantum state, each of which merits further consideration.[37]

[36] There are some interpretations of relativistic quantum reality for which fragmentalism could serve as a platform. For example on the wave functional interpretation, fragments could correspond to field configurations. (but see Baker 2015 for worries about wave functional interpretations). Concerning the problem of extra structure, one option is to invoke a privileged basis, for example the position basis. Here the fragmentalist would be far from alone. But the fragmentalist may also directly countenance the non-commutativity of observables by taking the relevant observables to participate in distinct situations. On one version of this picture, there is some kind of deep equivalence between a universe of fragments involving facts about position and a universe of fragments involving facts about momentum. On another version of this picture, there is a set of position-fragments and a distinct set of momentum-fragments, and a systematic correlation between the amplitude distributions across the two (and so for the elements of any set of non-commutable observables).

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