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On the possibility of submergence

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It is widely agreed that emergence is metaphysically possible. What about the converse, that is, *submergence*? Is it metaphysically possible as well? This is a substantive question that has been either utterly neglected (an exception is Bohn 2012) or quickly answered in the negative (Schaffer 2010). This neglect is not only significant in itself; the (im)possibility of submergence plays a crucial role in hotly debated topics in metaphysics, for example, the debate over Monism and Pluralism. This article is intended to prompt a discussion about metaphysical submergence.

In particular I will (i) provide examples of submergent properties, (ii) argue that these are metaphysically possible and finally (iii) propose a pluralist argument from submergence. First of all, some terminology should be set forth:

> (1) A property *P* is emergent iff (i) it is a natural property, (ii) it is instantiated by a composite object and (iii) it is not fixed by properties and relations of the proper parts of the composite object instantiating *P* (see McDaniel 2008: 131).

I am using the deliberately vague notion of 'fixing' for I want to stay neutral as to whether the notion in question should be cashed out in terms of, for

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example, reducibility, supervenience or some other 'determination relation'. Similarly,[1]

> (2) A property P is submergent iff (i) it is a natural property, (ii) it is instantiated by a proper part of a composite object and (iii) it is not fixed by the properties of any composite object it is a proper part of. (Schaffer 2010: 56)

The examples of submergent properties I will discuss draw on certain interpretations of quantum mechanics (QM). The plan is the following. In Section 1, I introduce some notions of QM that are used afterwards. In Section 2, I argue that particular QM interpretations – modal interpretations – provide examples of submergent properties and contend that such properties are metaphysically possible. In Section 3, I relate the emergence/submergence debate to the Monism/Pluralism debate.

1. *QM in a nutshell: states and properties*

To every physical system S_n, QM associates a (separable) Hilbert space H_n over the complex numbers. States of S_n are represented by normed vectors[2] in H_n. In any moderately 'realist interpretation' of QM states can be understood as representing a somewhat *indirect summary* of all the properties of physical systems (Miller 2013: 570).

(Types of) properties are referred to as observables, and mathematically represented by Hermitian operators O_n defined over H_n.[3] Particular values of these properties are the eigenvalues of O_n. This is enough for simple systems. As for composite systems, I will consider but a very simple case – that of a system S_{12} that is composed by *two* (atomic) proper parts, S_1 and S_2. The Hilbert space associated with S_{12} is the tensor product space $H_{12} = H_1 \otimes H_2$.[4] For any observable represented by O_1 defined on H_1 we can define an observable $O_1 \otimes I_2$ defined on H_{12}, where I_2 is the identity operator in H_2. We *could* think of these operators as representing the *same* property: in the first

1 We can assume that for every relation R between two distinct parts x and y of a whole w, we can 'construct' a property P of w expressed by the predicate: having two R-related parts. Arguably, properties so constructed will not qualify as natural. However, the arguments in the rest of the article will not depend on such properties.

2 Or, (almost) equivalently wavefunctions. Or, (almost) equivalently still, density operators.

3 Equivalently, a set of projective operators.

4 Some states in the tensor-product space, *entangled* states, cannot be written as simple tensor products of states of the parts. Thus, they are considered to represent emergent properties according to definition (1). See, for example, Schaffer 2010 and 2015 and Ismael and Schaffer forthcoming. For a critique, see Bohn 2012.

case, it is a property of system S_1 considered individually, whereas in the second case, it is a property of system S_1 considered as part of S_{12}. But, as Vermaas (1998) points out, there is no reason to do so – or, at least, none that comes from QM alone. As far as QM is concerned, Vermaas suggests that the observables are at least *theoretically* different insofar as they are defined over different Hilbert spaces.

2. *Modal interpretations of QM and submergent properties*

The core feature of modal interpretations (Lombardi and Dicks 2012) of QM is a distinction between the *dynamical state* – represented by the good old-fashioned quantum state summing up the properties that a system *might* have,[5] and the *value state* – that sums up the properties that a system *does* have:

> Modal interpretations are a class of interpretations of QM which, roughly speaking, *do not take the quantum state of a system to specify completely the properties of the system* . . . but take the quantum state itself . . . to prescribe or at least *constrain the possible range of properties* of the system. (Bacciagaluppi and Dickson 1999: 1165–1166)

The crucial question turns out to be the following: in what way are the quantum and the value state related? On a very influential version of the modal interpretation, one that is endorsed by Kochen (1985), and Dieks and Veermas (1995) – the quantum state alone determines the value state. Technical details involving the bi-orthogonal decomposition theorem[6] need not interest us here. The relevant point is that both directions of the following bi-conditional fail:

(3) $[O_1 = X] \,\text{iff}\, [O_1 \otimes I_2 = X]$

($[x]$ being the expected value of the observable in question). The left-to-right direction is known as *Property Composition*, whereas the right-to-left direction is known as *Property Decomposition*. In other words, failure of (3) entails that the expected value of the observable O_1 is different from the expected value of observable $O_1 \otimes I_2$. What this entails is that fixing the value state of the composite system *will not fix* the value state of the parts.

Consider two examples: I shall label them the *table example* – Arntzenius (1990) – and the *plane example* – Clifton (1996). Take a table and the property ‘colour’. Let ‘green’ be one of the possible values of the property

5 Hence ‘modal’.

6 To put it roughly, the theorem states that we can ‘divide’ any composite system in two parts S_1 and S_2 and then write the quantum state of the composite system so as to pick out uniquely orthonormal bases for H_1 and H_2. For technical details, Dieks 1988. Cf. also Vermaas 1998: 107–108.

'colour'.[7] Suppose the table has the property of 'being green at its left side'. Then we will have that

(4) The table is green at its left side

is true. Failure on *Property Decomposition* however entails that the left part of the table *does not* have the property of 'being green', that is

(5) The left side of the table is green

is not true.[8] In this case, we would say that the colour-property of the whole table fails to fix the colour-property of (one of) its parts, its left side. On the other hand, suppose (5) is true. Then failure of *Property Composition* entails that (4) is not.

As for a further example, take a 747-aeroplane and the property 'shape'. Let 'being warped' be one of the possible values of the property 'shape'. Consider the claims:

(6) The left-wing of the 747 has the property of being warped

(7) The 747 has the property that its left-hand wing is warped

Clearly (6) 'ascribes a property to a part of the plane, and [(7)] to the whole plane' (Clifton 1996: 385). Failure of (3) entails that if (7) is true, then (6) is not, so that the shape-property of the whole plane does not fix the shape-property of (one of) its parts, its left wing. The converse holds as well, that is, if (6) is true, (7) is not.

Thus, Vermaas writes

> So, one must accept that the questions of which properties are possessed by systems and subsystems are separate questions: the properties of a composite $\alpha\beta$ in general don't reveal information about the properties of subsystem α and *viceversa*. (Vermaas 1998: 114)

To further stress the point, failure of (3) shows that fixing the properties of the whole does not suffice to fix the properties of the parts,[9] as per the table (colour) and plane (shape) examples above.

7 To relate the table example to the general quantum description take S_1 = left side of the table; S_{12} = table; O_i ($O_i \otimes I_j$)= colour; x = green. The same applies *mutatis mutandis* to the plane example.

8 Whether it is false depends on whether one accepts *bivalence*.

9 For details concerning violations of both *Property Composition* and *Property Decomposition*, see Vermaas 1998: 110 and Clifton 1996: 386. Clifton notes that for a failure of *Property Composition*, 'any pure entangled state ... that determines density operators for its components that are not multiples of the identity will do', whereas, for *Property Decomposition* 'all one needs for its failure is a density operator ... that has non trivial projections of the form $O_1 \otimes I_2$ in the Boolean algebra of its spectral projections, but which determines density operators for its components ... that are mutliples of the identity' (Clifton 1996: 386 – notation adjusted). Density operators represent the quantum

Note that (3) fails for all the so-called state-dependent properties – that is, for instance, spin, position and momentum – at least some of which will inevitably qualify as *natural* ones. In effect, – among others – French (2010), Wolff (2012), and McKenzie (2014) have it that some of those properties are not only natural but also *essential* to quantum systems.[10]

Some potential objections to the argument just mentioned should be addressed.[11] First, one might object that it is not enough to show that a *certain property* of S_{12} fails to fix a certain property of S_1, for the latter may be fixed by *other* properties of S_{12}. Yet (3) is supposed to concern a property of a whole and a property of one of its parts that belong to the same *type*. Consider the examples above. The failure of (3) in those cases entails that the overall *colour of the whole*[12] does not fix the *colour of the part(s)*, and that the overall *shape of the whole* does not fix the *shape of the part(s)*. The point is that if colour-properties of the whole do not fix colour-properties of the parts, then no other property of the whole will, for it is not the case that properties of some other type – such as shape properties – fix colour-ones.

Second, contrary to what one may think, (3) fails for *any* whole S_1 is a proper part of. Take any such whole w, and let S_2 be the mereological complement of S_1 with respect to w. The very same argument will hold. In what follows, I will focus on a particular whole, the universe. By taking S_2 to be S_1's mereological complement with respect to the universe, one will be able to run the same argument.[13]

The conclusion I aim to draw is the following: it seems that properties of the parts of quantum systems are, in such modal interpretations, paradigmatic examples of submergent properties.[14]

Schaffer (2010) argues that submergence is impossible because

> any intrinsic property of the proper parts *ipso facto* correlates to an intrinsic property of the whole, namely, the property of having-a-part-with-such-and-such-intrinsic-property. (Schaffer 2010: 56)

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state here – see footnote 6. Both Vermaas and Clifton go on to provide some such examples themselves.

10 Thanks to an anonymous referee.

11 Thanks to an anonymous referee.

12 That is, a complete description of the 'colour-distribution' of the whole.

13 In fact, we can easily conceive a quantum-modal-world with just three things: two *atomic* systems S_1 and S_2 and their fusion S_{12}.

14 It should be noted that, given the failure of *Property Composition*, properties of the whole are, on the other hand, examples of *emergent properties*.

But the argument I gave above shows that this is not the case in (some) modal interpretations. In effect, properties of the parts *do not correlate in any significant way with properties of the whole*.[15]

My point may be challenged as follows: Schaffer's argument contends that, for any property P_i of any part, P_i correlates to the property of the whole expressed by the predicate 'having a P_i-part'. However, in the table example, I appealed to the property of the whole expressed by the predicate 'being P_i-at-the-region-where-the-part-is-located'. 'Having a P_i-part' and 'being P_i-at-the-region-where-the-part-is-located' are different predicates. One might argue that they express *different properties*. Yet, I contend that as far as QM is concerned, these predicates *do* express the very *same property*, insofar as they are represented by the *same operator*, that is $O_1 \otimes I_2$. An Hermitian operator is associated with *only one* property: *same operator*, *same property*. And in effect the plane example is crystal clear on this respect, for it uses the very predicate that Schaffer appeals to – that of 'having a P_i-part'.[16]

To conclude the argument, one just needs to show that modal interpretations describe metaphysically possible worlds. One argument may be the following: worlds described by modal interpretations satisfy the criteria for metaphysical possibility, as discussed in, for example, Bohn (2009) and Cotnoir (2016) – that is, *conceivability*, *advocacy* and *consistency*.

I will not focus on the details of such an argument here in view of the fact that these kinds of argument are notoriously controversial. Yet a further argument may be set forth: worlds described by the modal interpretations are taken to be *physically possible*, insofar as they are compatible with quantum laws. Thus, even a mild naturalism, according to which the set of physically possible worlds is a (proper) subset of the set of metaphysically

15 This is true for all 'non-modal' properties in the value state of the system.

16 One might still have further concerns. One might object that it is still unclear that these properties are indeed represented by the same operator $O_1 \otimes I_2$, insofar as the property mentioned by Schaffer is specified in ordinary language, whereas the Hermitian operator is specified in highly complex theoretical terms. The reply is two-fold: on the one hand, as the plane example highlights, physicists do in fact routinely use that operator to represent that property: 'If we let O_1 represent the proposition above, about the left-hand wing of the 747 being warped, then, *clearly* the second proposition, about the left-winged part of the 747 being warped is of type $O_1 \otimes I_2$' (Clifton 1996: 385). One might still insist that physicists have no right to do so. Yet, I contend, the burden of the proof is on the objector. On the other hand, the claim that the property Schaffer appeals to is not represented by that operator boils down to the idea that it is not representable by any other operator, for no other candidate is even remotely plausible. This would amount to say that there is a property that cannot be represented by the operators of the quantum formalism. To be fair, there are some interpretations of QM where this is the case, the so-called hidden variables interpretations. Bub 1997 argues that *some* modal interpretations are examples of hidden variable interpretations. But, it should be noted, *these are not the modal interpretations that are relevant here.* They are exactly those interpretations in which the quantum state alone *does not* determine the value state. Thanks to an anonymous referee here.

possible worlds, will make it the case that they are metaphysically possible. If so, these worlds are metaphysically possible, and insofar as there are submergent properties in these worlds, submergence is metaphysically possible as well.

3. *Submerging Monism?*

To conclude, I will relate the discussion above to a further debate – the one concerning Monism and Pluralism. Roughly, Monism has it that there is just one fundamental entity, whereas according to Pluralism there are at least two. Schaffer's *Priority Monism* is one of the most interesting versions of the former view. Priority Monism is the thesis that the universe, that is, the mereological fusion of all material objects, is the only fundamental entity.[17] One of the most powerful arguments for Monism is a case from emergence. If emergent properties are possible, then there is some pressure to say that wholes exhibiting such properties are wholes that do not depend on their parts – or so Schaffer contends. The case for the last claim is an argument from *duplication* and *completeness*.

Consider a whole w and its proper parts $x_1, \ldots, x_n$, and suppose w features an emergent property P. Given that P is not fixed by properties and relations exemplified by $x_1, \ldots, x_n$, *duplicating* them will fail to duplicate relevant facts about w. Let us say, following – and slightly adapting –[18] Schaffer (2010: 39) that a plurality of parts is *complete* for a whole it composes iff duplicating all these parts, while preserving their fundamental relations, metaphysically suffices to duplicate the whole. Then in general – so the argument goes – if a whole exhibits an emergent property, nothing short of the duplication of the entire whole will be enough to guarantee completeness, that is, to completely characterize the whole in question. Given that a plurality of 'fundamental' parts of a whole should be complete for that whole (Schaffer 2010: 55), we should claim that wholes with emergent properties *do not depend upon their parts*. Schaffer assumes that relations of ontological priority – or relative fundamentality – between concrete objects form a well-founded partial order that reflects 'what depends on what' (Schaffer 2010: 35).

17 Schaffer (2010, 2015), and Ismael and Schaffer (2016).

18 This is a slight adaptation of Schaffer's way to characterize the notion of completeness insofar as Schaffer does not explicitly mention that a plurality of parts is complete *relative to a given whole*. In the relevant passage, Schaffer is explicitly considering a particular whole – that is, the *universe*. However, Schaffer himself sometimes uses the notion of completeness relative to an arbitrary whole: '[N]othing will suffice to *completely* characterize an object with emergent properties short of that whole object, or any wider whole that object is a part of.' (Schaffer 2010: 55). When the relevant whole *is* the entire universe, one might then define *completeness simpliciter* as *completeness relative to the universe*. Since the argument for Monism I will consider explicitly focus the universe, nothing substantial hinges on this point.

Furthermore, *mereological relations induce dependence relations*: if there is a mereological relation between *x* and *y*, then there is a dependence relation between *x* and *y* as well. It follows that a whole with emergent properties is *more fundamental* than its parts. The argument from emergence to Monism is simple:

(8) The Universe can exhibit emergent properties;

(9) If a whole can exhibit an emergent property it is more fundamental than its parts;

(10) The Universe is more fundamental than its parts.[19]

Schaffer argues that every answer to the question of fundamental mereology – what are the metaphysically fundamental entities – must respect the *Tiling Constraint* (Schaffer, 2010: 38–39; 2015: 24–25), the conjunction of the following two claims:

(11) The mereological fusion of the fundamental entities is the universe;

(12) No two distinct fundamental entities overlap each other.

Given this, Monism follows from (10), the *Tiling Constraint*, plus the fact that the universe is mereologically maximal. If the universe is more fundamental than its parts, then it is fundamental *simpliciter*,[20] that is, it does not depend on anything else, for everything else is part of it. And if the universe is fundamental then nothing else could be, on pain of failing conjunct (12) of the *Tiling Constraint*. In fact, anything that is distinct from the universe overlaps it.

Now, were submergence metaphysically possible, we would then by parity of reasoning have, it seems, an argument for Pluralism. Let me introduce some jargon. Say that a whole *is complete for a plurality* of its parts iff duplicating the whole metaphysically suffices to duplicate all the relevant facts about those parts. I shall call it the *Part/Counterpart of Completeness*. I also need the following *Restricted Version of the Tiling Constraint* to a particular whole *w*. For any whole *w* composed by some proper parts:

(13) The sum of the fundamental parts of *w* is *w*;

(14) No two distinct fundamental parts of *w* overlap.[21]

19 Note that the formulation of the argument in (6)–(8) states that the universe *can* exhibit emergent properties – not that it *does* exhibit them. Yet Schaffer argues that Monism and Pluralism are metaphysical theses that are necessarily true if true at all. See Schaffer 2010: 55–57. This last claim is far from uncontroversial – see for example, Cameron 2007, Miller 2009 and Wildman forthcoming.

20 It follows from *well-foundedness* that something has to be fundamental *simpliciter*.

21 These characterizations may be made more precise – yet they suffice for my purpose here.

Consider a whole w and one of its proper parts x_1 that exhibits a submergent property P^*. Duplicating w, will fail the *Part/Counterpart of Completeness* for it will fail to fix relevant facts about x_1. Duplicating x_1 is actually necessary to guarantee the *Part-Counterpart of Completeness*, that is, to fix all the relevant facts about x_1. However duplicating x_1 alone will result in failing conjunct (13) of the *Restricted Version of the Tiling Constraint* as applied to w. At least two things should be duplicated to metaphysically duplicate w.[22]

I contend that if the duplication argument warrants that, in the case of emergence, a whole is more fundamental than the parts – for duplication of the whole is necessary to fix all the relevant facts about it – then in the case of submergence, it warrants the following: if a proper part of a whole can exhibit a submergent property, then at least two proper parts of that whole are more fundamental than the whole itself. For duplication of at least two proper parts is necessary to fix relevant facts about both the parts and the whole. The argument for Pluralism parallels the one for Monism:

(15) Proper parts of the universe can exhibit submergent properties;

(16) If a proper part of a whole can exhibit a submergent property, at least two of its proper parts are more fundamental than the whole;

(17) At least two distinct parts of the universe are more fundamental than the universe.

Claim (17), together with the *Tiling Constraint*, entails that at least two things are fundamental *simpliciter*. And this amounts to Pluralism. To see this, note that it follows from (17) that the universe is *not* fundamental. So, from conjunct (11) of the *Tiling Constraint*, it follows that at least two of its proper parts are.

Despite the fact that Schaffer never explicitly discusses such an argument, he is indeed aware of its possibility, so that he explicitly denies (15). Yet if the arguments I considered are on the right track, submergence is possible after all. As with any philosophical argument, the one I set forth in favor of the possibility of submergence is hardly definitive. But I hope I said enough to re-

22 Note that it is still true that when a whole exhibits an emergent property duplicating any plurality of proper parts will not be enough to duplicate the whole. In fact, if a whole exhibits an emergent property and one of its proper parts exhibits a submergent property the (*Restricted*) *Tiling Constraint* should be reformulated, in particular its 'Overlap conjunct'. Yet, this is *not* the conjunct that is used in the argument in the main text. A fully fledged discussion of such issues is beyond the scope of this article. If a whole does *not* exhibit any emergent property but one if its proper parts exhibits submergent properties, duplication of that very proper part and its mereological complement would suffice to duplicate the whole. Thanks to an anonymous referee here.

consider the question of the (metaphysical) possibility of submergence more thoroughly. And in turn, this might give some hope to pluralists. In the end, we might ascend and emerge to the surface of the One, but we may also plunge and submerge into the depths of the Many.[23]

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Fictional realism and metaphysically indeterminate identity

WOUTER A. COHEN

1. Introduction

Fictional realism is the thesis that there are fictional characters. One obvious advantage of supposing there to be fictional characters is that sentences like 'Sir Arthur Conan Doyle created Sherlock Holmes' can be straightforwardly true, because 'Sherlock Holmes' really refers.[1] One obvious complication is that fictional realists are committed to many abstract objects. Perhaps the cost is worth it; whether the scale tips in favour of the realist is of course a central question in most ontological debates.[2] But the fictional realist faces more difficulties than arguing that accepting fictional characters into our ontology is worth the trouble. Anthony Everett (2005) has argued that

1 This is at least the case for the perhaps most adhered to account of fictional realism right now: Amie Thomasson's (1999) artifactual theory (also known as creationism).

2 Additionally, one might wonder what exactly the cost is. Thomasson (2015), for instance, defends a so-called easy ontology. For an overview of her interesting metaontology, see Thomasson 2015.

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