9 The Special Power-Composition Question and the Powerful Cosmos

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The Special Power-Composition Question

Any account holding that 'objects are built out of powers' (Marmodoro 2017: 110) faces an immediate question: In what circumstances do some powers compose an object? This question is structurally analogous to the more familiar mereological question: In what circumstances do some parts compose an object? (e.g., Van Inwagen 1990: 29). The similarity between the two questions licenses a convenient label for our topic. Let us call it the *special power-composition question*.[1]

To assess the tenability of any power mereology view, namely any theory claiming that objects are composed of powers, we must consider how it answers the special power-composition question. In the mereological case, we find two main types of approaches: *radical* (or 'extreme') and *moderate* (or 'restricted'). In turn, radical views are divided into 'mereological nihilism' and 'mereological universalism'.[2]

Schematically, we can say that mereological nihilism is the view that it is never the case that some parts (when they are two or more) xs compose an object y because, necessarily, nothing is such that the xs compose it. Mereological nihilism entails that there are no composite objects. The only existing objects are mereological atoms lacking any proper parts. Mereological universalism is the converse of nihilism. This view holds that it is always the case that the xs compose some y because, necessarily, something is such that the xs compose it. Moderate approaches deny both mereological nihilism and universalism. On these views, sometimes but not always, the xs compose y. For example, Van Inwagen defends the idea that there is something composed by the xs when the 'activities of the xs constitute a life (or there is only one of the xs)' (1990: 82). Here I do not aim to discuss Van Inwagen's view. I offer it as an example of a moderate answer to the special composition question. Since it is not always the case that the xs constitute a life, composition is restricted.

The preceding approaches to the special composition question have counterparts in the mereology of powers. We can schematically formulate them as follows. 'Power-nihilism' is the view that it is never the case that there is some *y* composed by a plurality of powers *P*s because, necessarily, nothing is such that the *P*s compose it. 'Power-universalism' is the converse of power-nihilism. It is the view that it is always the case that the *P*s compose some *y* because, necessarily, something is such that the *P*s compose it. Moderate answers to the special power-composition question deny both power-nihilism and power-universalism. Moderate approaches hold that sometimes but not always, there is some *y* that is composed of the *P*s. In the next section, I illustrate some reasons why a power mereologist should favour a moderate approach. But first, I clarify the chapter's aims.

Here I explore an application of Anna Marmodoro's (2017) moderate approach to the special power-composition question. On the Marmodorean view, which I unpack in due course, an object is composed by a plurality of powers when they form a structure that is both physically united and metaphysically unified. I argue that this two-fold condition, which I name the 'Marmodoro Condition', rules out some implausible consequences that radical answers to the special power-composition face. However, the main goal of the chapter is different. I endeavour to show that the Marmodoro condition, coupled with plausible considerations from quantum theory, entails the existence of the *powerful cosmos* – an object composed of all the compossible fundamental powers instantiated across the universe. Advocates of the Marmoderan view and other similar moderate approaches might experience an intuitive resistance to the powerful cosmos on the grounds of its apparent implausibility. In this chapter, I defend the opposite view: we should embrace the powerful cosmos. I make my case by arguing that there are three considerations, which I indicate in the following, for thinking that a moderate power mereology view accepting the existence of the powerful cosmos is preferable to one that rejects it. My conclusion is that the existence of such an object is a beneficial consequence of the Marmodorean view.

Here is the plan. In the remainder of this section, I clarify how I understand powers. I also elucidate some important differences between power mereology and the mereology of parts. In the next section, I offer two considerations for preferring a moderate approach to the special power-composition questions over the more radical power-nihilism and power-universalism, respectively. In the third section, I illustrate Marmodoro's moderate approach to power composition. I turn my attention to the powerful cosmos in the fourth section. There I discuss an argument for the existence of such an object, drawing from plausible considerations about the metaphysics of quantum entanglement. In the final section, I argue that proponents of the Marmodorean view and similar approaches should

welcome the powerful cosmos. In that section, I offer three reasons – one metaphysical, another empirical, and a further other methodological – for thinking that a moderate approach that embraces the powerful cosmos is preferable to one that does not. I close by pointing out an interesting yet unexplored connection between the emerging power mereology view and priority monism, namely the view that the cosmos is a fundamental whole prior to its parts.

Before we proceed any further, two issues must be clarified. The first one concerns the metaphysics of powers. In what follows, I will remain neutral on the nitty-gritty details of the operative conception of powers. Diversity abounds among theories of powers (for a recent overview, see Tugby 2020). But here I am concerned with a more general discussion of the special power-composition question. This task does not require us to adopt a specific conception. My arguments can be reframed for more specific views if one wishes. I shall take powers to be actual properties whose nature or essence is to be directed toward certain effects that are manifested in distinctive circumstances. These effects may involve the instantiation of other powers. Powers thus have a fixed modal profile, but they need not be constantly manifested. My focus will be on *fundamental powers*, but I will omit the qualifier for the sake of brevity. Putative examples of fundamental powers are *charge*, *mass*, and *spin*. Following the orthodox view amongst theorists of powers, I shall take powers to essentially contribute to the causal or dispositional profile of their bearers. As Chakravvartty puts it, powers 'are quintessentially causally relevant properties – they empower things that have them to behave in certain ways in certain circumstances' (2017: 107). One might say, for example, that a charged particle produces an electromagnetic force when in motion by virtue of instantiating the powerful property of having a determinate charge.

The second clarification is about the difference between the mereology of powers and that of parts. One might expect that the mereological principles that govern parthood relationships of the form 'the xs are part of y' extends to power-parthood relationships of the form 'the Ps are part of y'. But such an expectation might be misplaced. To start, we should note that the power mereology view under scrutiny is not explicitly committed to the axioms of classical mereology (the theory stemming from the work of Leśniewski [1916, 1927–1931], and Leonard and Goodman [1940]). Nor does the viability of the power mereology view demand them. Here are the axioms:

Reflexivity: for every x, x is part of x.
Antisymmetry: for every x and for every y, if (x is a part of y and y is a part of x), then x is identical with y.
Transitivity: for every x, for every y and for every z, if (x is a part of y and y is a part of z), then x is a part of z.

These structural principles may fit the mereology of powers. But they appear to be negotiable. The discussion of the Marmodorean view and the powerful cosmos does not force us to embrace them. As such, I will leave these matters open.

A related elucidation concerns the difference between composition and power-composition (i.e. composition of powers). It is unclear how deep the similarities between these two notions run. A typical formulation of mereological composition is this: the *x*s compose *y* just in case 'the *x*s are all part of *y* and no two *x*s overlap and every part of *y* overlaps at least one of the *x*s' (Van Inwagen 1990: 29; the *x*s overlap is they have a common part). It is far from obvious whether we should impose some constraint about overlap on the powers composing an object. Unfortunately, things get messy. Presumably, an answer to the overlap constraint for powers implies an answer the *general* power-composition question, namely the question of what power-composition is. Regrettably, I have no insightful proposal to offer (recall that my focus is on the *special* power-composition question). But here is the important bit. It might be that power-composition is a *sui generis* relation, one which bears some similarities to parthood composition but is metaphysically distinct from it. Accordingly, we should be more cautious in distinguishing between these two forms of composition. For the sake of readability, however, I use 'composition' instead of 'power-composition' when it is evident that I refer to the composition of powers. Finally, I shall assume that power-composition is not identity.

Why Adopt a Moderate Approach to the Special Power-Composition Question?

A power mereologist has compelling reasons for rejecting both power-nihilism and power-universalism. I outline these views in this section, starting with the former. Power-nihilism denies the existence of objects composed of powers. This approach is in tension with the very reason for adopting a mereology of powers in the first place. Arguably, a chief motivation for embracing this view is the desire to offer a metaphysical account of composite objects in terms of their powerful parts. This project presupposes that at least some objects can be composed of powers. But power-nihilism rejects this very claim. It would be uncharitable to regard power mereologists as engaged in a self-defeating project. Therefore, power-nihilism is not a plausible option for them.

Power-universalism does not evidently clash with the prospects of the power mereology view. But a different consideration gives power mereologists reasons to favour an alternative approach. Power-universalism does not harmonise with the commitment to the so-called *Eleatic Principle*.

This tenet expresses the idea that the mark of being of a thing is its power to affect and be affected by other things. Here is a passage illustrating the thought:

> I suggest that anything has real being that is so constituted as to possess any sort of power either to affect anything else or to be affected, in however small a degree, by the most insignificant agent, though it be only once. I am proposing as a mark to distinguish real things that they are nothing but power.
>
> (Sophist 247d–e; from Heil 2003: 75)

All or many theories of powers subscribe to the Eleatic Principle or something in the vicinity. Since it is a theory of powers, the power mereology view should presumably do the same.

The problem with power-universalism is that it entails the existence of composite objects that pass the Eleatic test suspiciously. As I explain in the following, this form of 'ontological cheating' calls into question whether such objects deserve genuine being. An example will illustrate.

Let us suppose that instances of *charge* are fundamental powers. Now consider an instance of *charge* in Birmingham and another in Glasgow. Power-universalism entails that there is an object, say o, these powers compose. Does o pass the Eleatic test? In a sense, it does. The parts of o are instances of *charge*, and these indeed have the power to affect or be affected by other things, such as other instances of *charge*. But does o deserve to be considered a 'real thing' *on these grounds*?

Two closely related considerations suggest we favour a negative answer. First, objects like o, which come into existence because of the truth of power-universalism, may lack physical unity. Second, they are also disunified in a metaphysically relevant sense.

An object like o lacks unity because power-universalism, on its own, does not ensure that its parts – namely the Birmingham *charge* and the Glasgow *charge* – are physically 'glued' together. On power-universalism, composition is cheap. There is always something that a plurality of powers Ps composes. But this view cannot guarantee that the Ps stand in some physical relationship that would ground their unity in every case.

For a kindred reason, power-universalism does not guarantee that objects such as o display unification. Cheap composition of the sort licensed by power-universalism does not warrant that the parts that compose an object form a unified whole. For example, the fact that o has the parts it has does not depend on its nature. Nor does it seem that it lies in the natures of the Birmingham *charge* and the Glasgow *charge*, respectively, that they compose o. The existence of o is nothing but a consequence of an unrestricted principle of power-composition.

To drive the point home, I suggest we compare *o* with an object that displays both unity and unification. Think of an electron. Its determinate *charge*, *mass*, and *spin* are plausible fundamental powers. On the power mereology view, we could argue that these powers compose the electron. Unlike *o*, the electron displays a structural cohesion among its parts. Science, for all we know, tells us that electrons and their specific determinate properties come into and go out of existence altogether. By contrast, no similar considerations apply to *o*. Moreover, the possession of determinate powers seems to be constitutive of the nature of an electron. That is, it appears to be lying in the essence of electrons that they possess such specific powers. An analogous a link is hard to justify for *o*.

To be clear, I do not wish to suggest that the preceding considerations render both power-nihilism and power-universalism hopeless. There might be ways to salvage these views. But until these strategies are proved successful, the power mereologist should regard the adoption of a moderate answer to the special power-composition question as a more promising way to evade the previously mentioned issues. By admitting that sometimes, but not always, powers compose objects, a moderate approach does not generate a methodological tension with the goals of the power mereology view. And a moderate approach is not forced to admit the existence of composite objects such as *o* that lack cohesion and integration. However, the challenge for this approach is to specify under what circumstance a plurality of powers composes an object in a way that displays both physical unity and metaphysical unification. Lucky us: Marmodoro (2017) offers a theory that does just that.

Marmodoro's Moderate Approach

On Marmodoro's view, power composition occurs when a certain condition is satisfied (Marmodoro 2017: 118–119; note that Marmodoro's presentation of the condition is slightly different). We can formulate it as follows:

Marmodoro Condition (basic): there is something a plurality of powers *P*s compose if and only if the *P*s are (1) physically united and (2) metaphysically unified.

The Marmodoro Condition can be further sharpened, depending on one specific view of powers. Here this generic formulation will suffice for illustrating Marmodoro's account. Accordingly, for example, an electron is composed by its determinate *charge, mass*, and *spin* (assuming that these are powers) when these both are physically united and metaphysically unified. On Marmodoro's view, when a structure of powers is metaphysically unified (and not just physically united), the composite object emerges as a

powerfully unified individual: a 'substantial power' (in Marmodoro's terminology; 2017: 120). To use the previous example, we could say that the electron is the substantial power constituted by (but not reducible to) and emerging from its structure of powers (namely *charge*, *mass*, and *spin*). There are some interesting and intriguing issues concerning the notion of emergence at play in Marmodoro's view. But in what follows, my focus is on the conditions a structure of powers must satisfy to yield a substantial power. To avoid confusion, however, I will keep using the more familiar 'composite object' to refer to a substantial power.

The adoption of the Marmodoro Condition yields a moderate answer to the special power-composition question. According to Marmodoro, not all pluralities of powers satisfy it. This amounts to a rejection of power-universalism. But since some pluralities do form physically united and metaphysically unified structures, this approach also denies power-nihilism.

Now I turn to illustrate clauses (1) and (2) encoded in the Marmodoro Condition, starting with the idea of physical unity.

As I understand it, a physically united structure of powers displays various ontological dependency relations among its constituent powers (Marmodoro 2017: 119). There is a staggering abundance of more specific ontological dependencies (see Lowe [1994] and Correia [2005] for an overview). The Marmodorean account is sufficiently flexible to accommodate various options. Here we can liberally use 'ontological dependence' as a placeholder for whatever more specific 'small-d' dependence relation one might have in mind. Such ontological dependencies can be both causal and metaphysical. What matters is they impose 'physical continuity and connectedness, synchronically and often diachronically' (Marmodoro 2017: 119) among the powers in the plurality.

An important specification of Marmodoro's account is that the relevant ontological dependencies stem from the nature of powers, namely from their directedness. Accordingly, it is the nature of powers that determines how they become physically united. Fortunately for us, Marmodoro suggests that some familiar objects display physical unity among their powers. Functionally organised artefacts such as laptops and living organisms, like you and me, are plausible examples of entities constituted by physically united structures of powers. The difficult question is, of course, whether these objects are also metaphysically unified. Here we should expect disagreement. The examples are, here and in Marmodoro (2017), best regarded as merely illustrative. Now let us turn to metaphysical unification.

Under what circumstances is a plurality of physically united powers metaphysically unified? This passage answers the question:

> My claim is that the difference between a structured plurality and a single individual it may constitute lies in the ontological dependencies that develop between the components of the structure. Unification of

the structured components into a single individual 'interferes' with the components that are unified into one. The structured components become unified into one individual by being re-individuated in terms of the whole. This involves more than ontological dependence; it involves holistic dependence.

(Marmodoro 2017: 120)

We can extrapolate two components of the mechanism of metaphysical unification. First, a plurality of physically united powers becomes unified when it displays holistic dependencies. Second, the process of metaphysical unification amounts to the re-individuation of the powers as *qualifications* or *ways of being* of the whole. Once unified, the powers 'cease being discrete entities in the structure and become qualification of the individual' (Marmodoro 2017: 120). When the *mass*, *charge*, and *spin* of an electron become unified, assuming that these are its constituent powers, they are re-individuated as ways of being of the electron (for more on a conception of properties as ways of being, see Levinson [1978] and Heil [2003]).

Putting these pieces together, we can refine the initial formulation of the Marmodoro Condition as follows. Since my focus for the remainder of the chapter is on the refined version, I will omit the qualifier.

Marmodoro Condition (refined): there is something y a plurality of powers Ps compose if and only if the Ps and y (1) display some holistic dependencies and (2) the Ps are re-individuated in terms of y.

There are various ways in which the notions of holistic dependence and re-individuation can be unpacked, depending on one's favourite view. Here I will employ a relatively neutral conception, which I discuss further in the next section. Minimally, I regard holistic dependence as schematically formulated along these lines: the Ps and y are holistically dependent just in case the Ps both depend on each other and on y. And I shall take, again minimally, that re-individuation of Ps in terms of y entails that the Ps cannot be removed from y or re-arranged without destroying y. An analogy will illustrate. We might think of a plurality of physically united powers as something like a Lego construction where the bricks are physically connected yet discrete entities that can be freely re-arranged. A plurality of metaphysically unified powers is something like a Lego construction whose parts are no longer identifiable as discrete bricks; they cannot be picked and moved around.

My aim is not to defend the correctness of the Marmodoro Condition. As such, I will not attempt to make it more precise. To repeat the goal of this section, I presented Marmodoro's account as an illustration of a well-motivated moderate approach to the special power-composition question.

Things like dogs, electrons, and trees are plausible candidate entities satisfying the Marmodoro Condition. Things like the object *o* or the sum of my hand, your copy of *On the Plurality of Worlds*, and a tea leaf in Jiangnan intuitively fail to satisfy it. Unsurprisingly, controversy over specific cases is inevitable and predictable. I will not attempt to settle the question of whether a specific item, say, a neuron, is really a unified whole composed of powers. Instead, I wish to explore a *prima facie* surprising and more philosophically interesting consequence of Marmodoro's moderate approach. Coupled with plausible considerations from quantum theory, the Marmodoro Condition entails the existence of an object composed by all the compossible fundamental powers instantiated across the universe. I call this object the *powerful cosmos*.

The Argument for the Powerful Cosmos

In this section, I discuss an argument for the existence of the powerful cosmos. In its simplest form, we can build it like this.

1) *Cosmic Entanglement*. Some considerations from quantum theory suggest that the universe as a whole is a vast entangled system.
2) *Holistic Dependence*. Entangled systems display holistic dependencies among their components.
3) *Power Mereology View*. The components of the entangled universe are all the compossible fundamental physical powers instantiated across the cosmos.
4) *Marmodorean Link*. If we adopt the Marmodoro Condition, then there is a metaphysically unified object composed by all the compossible fundamental physical powers instantiated across the cosmos.

   Assuming the Marmodoro Condition for the sake of the discussion, we reach the following:

5) *Powerful Cosmos*. There is a metaphysically unified object composed by all the compossible fundamental physical powers instantiated across the cosmos.

This argument is admittedly speculative. But I offer it in an exploratory spirit. Recall that my overall goal, which I establish in the next section, is to argue that the existence of the powerful cosmos is a beneficial consequence of the Marmodorean moderate approach and similar accounts. I shall not attempt to settle difficult questions concerning the correct interpretation of the formalism of quantum mechanics. Similarly, I will refrain from diving into complicated technical matters that will confuse the discussion unnecessarily. Instead, I wish to discuss the argument for the powerful cosmos in its full generality, leaving open insofar as possible certain

details concerning its implementation into physical theory. Having clarified the scope of the argument, I turn to explain each premise.

Let us start with *Cosmic Entanglement*. An entangled system is one whose wave function cannot be reduced to the wave functions of its components. The probabilities of joint outcomes of measurements carried over the entangled components are not the product or combination of the outcome probabilities of each separate component. In a more informal way, as Ismael and Schaffer put it, we can say that the components of an entangled system behave in ways that are 'individually unpredictable but jointly constrained so that it is possible to forecast with certainty how one component will behave, given information about the measurements carried out on the other(s)' (2020: 4141). Suppose, for example, that particles Amira and Beke are entangled with respect to their x-spin such that their joint state has total x-spin 0. The quantum formalism predicts systematic anti-correlations: if Amira measures x-spin up, then Beke measures x-spin down, and vice versa.

The *Cosmic Entanglement* premise expresses the idea that the universe as a whole can form a vast entangled system. This premise might well be the most controversial of the entire argument. I discuss some objections against it in the next section. Here I outline two ways, defended by Schaffer (2010: 52) and Ismael and Schaffer (2020: 4150), the idea of an entangled universe can be made more plausible.

The first way is physical. If we assume that the Big Bang is the starting point of the universe at which everything interacts, we obtain an initial entangled state. If we also assume that the world evolves in accordance with Schrödinger's equation, then the initial entanglement is preserved. It is worth noting that even without the initial entanglement, assuming that the world evolves in accordance with Schrödinger's equation, we may reach the entangled universe as its evolution tends to spread entanglement.

The second way is mathematical. If there is a wave function of the whole universe, it is 'almost certainly entangled' (Ismael and Schaffer 2020, p. 4150) as it should measure 1. All wave functions measuring 1 are entangled. In the absence of a wave function collapse, one should 'expect universal entanglement' (Schaffer 2010: 52).[3]

The *Cosmic Entanglement* premise has wider implications that go beyond what I want to achieve in this chapter. For example, we might wonder what reality is fundamentally like if we embrace this premise (for more on this, see Ismael and Schaffer 2020: 4151–4154). Discussing such a topic would leave us far astray from the different and more modest goals of the chapter, namely defending the fruitfulness of the powerful cosmos. Here we should note two things. First, my claim is not that *all* physical interpretations support *Cosmic Entanglement*. Second, our focus should be on the conjunction between *Cosmic Entanglement* and the other premises, which yields the conclusion that the powerful cosmos exists.

Now let us consider the *Holistic Dependence* premise. As with the Marmodoro Condition, there are various ways to precisify the notion of holistic dependence. On the minimalist conception adopted earlier, a plurality of powers is holistically dependent just in case they depend on each other and on the whole they compose. It seems to me that this interpretation is naturally suited to making sense of the holistic dependence displayed by entangled systems. For example, Schaffer (2010, 2013) and Ismael and Schaffer (2020) take entangled components to be dependent not only on each other but also on the entangled system as a whole. Consider the example of Amira and Beke, the two entangled particles. Call Amira+Beke their entangled system. The wave function of Amira+Beke is not the product of the wave functions of Amira and Beke. However, because they are entangled, we know that the measurement outcomes of Amira and Beke are jointly constrained in an anti-correlated fashion that strongly suggested a mutual dependence between them. But assuming that it is not brute, what explains the mutual dependence between Amira and Beke?

Holistic approaches to entanglement would argue that Amira and Beke are dependent on the composite system Amira+Beke. On these views, it is the quantum entangled system as a whole that contains more information about the observable behaviour of its modally correlated components – rather than the other way around. As such, the components of an entangled system do not just depend on each other. They also depend on the whole entangled system. We should note, and this is crucial for the discussion of the argument for the powerful cosmos, that *Holistic Dependence* is not confined to systems of two particles (such as Amira+Beke). It extends to systems as vast as the universe. Given the *Cosmic Entanglement* premise, *Holistic Dependence* implies that the universe displays holistic dependencies among its parts.

Schaffer would make a further claim (2010: 45–50): because the entangled components are dependent on the whole entangled system, the whole is prior to its parts.[4] Here we do not need to follow this approach. For example, the power mereologist is not forced to accept that the holistic dependency exhibited by the universe and its parts yields a priority claim. Thus, we should distinguish between a priority version of the argument, leading to the conclusion that the powerful cosmos exists and is more fundamental than its powerful parts, and a non-priority version committed solely to the existence claim. Here I am discussing the latter. I will therefore remain neutral on whether the *Holistic Dependence* premise should nudge power mereologists to follow Schaffer in defending the priority of the cosmos over its parts. But I will return to this view at the end of this chapter. Concluding this digression, I stress that the point of the discussion is that we can defend the *Holistic Dependence* premise by endorsing a holistic approach to entanglement.

As for the *Cosmic Entanglement* premise, also *Holistic Dependence* raises critical technical questions about the physical interpretation of quantum formalism. Here I wish to stress, once again, that my interest is in exploring the argument for the powerful cosmos inasmuch as it is a philosophically surprising consequence of the power mereology view (in conjunction with certain physical considerations). Such an intellectual exercise retains its value even if we do not dive into the nitty gritty of physics. Given this goal, I focus the discussion on the motivations for endorsing *Holistic Dependence* and then discuss the argument's implications for the metaphysics of powers.

Why would a power mereologist endorse *Holistic Dependence*? Arguably, the main reason concerns the general appeal of this interpretation for making sense of the modal connectedness of entangled components. For example, the power mereologist could agree with Ismael and Schaffer (2020: 4142–4144). They argue that accepting a holistic dependence view of entangled wholes is preferable to both hidden variable approaches and interpretations that embrace nonlocality (and, consequently, superluminal influence). In short, Ismael and Schaffer argue that

> [t]here is a deeper implausibility to both incompleteness and nonlocality: both are ways of denying that the quantum state provides a complete description of systems, differing only in whether the additional "hidden variables" posited operate locally or not.
>
> (2020: 4144)

On their preferred interpretation, what explains the systematic anticorrelations among the individual entangled components is the fact that their respective intrinsic states are determined by the state of the entangled system as a whole. The underlying idea is that the entangled composite system contains more information, encoded by the formalism of the wave function, than the individual entangled components (Ismael and Schaffer 2020: 4145–4147). The claim here is *not* that hidden variable approaches and interpretations embracing nonlocality are hopeless. In fact, I shall suspend judgment on Ismael's and Schaffer's assessment of the prospects of these views. Instead, the point is that the power mereologist can appeal to similar considerations for supporting *Holistic Dependence*.

The third premise expresses a consequence of the power mereology view. Recall that the latter view endorses a conjunction of two claims. The first is that all fundamental physical properties are powers. The second is that fundamental powers compose objects when the Marmodoro Condition, as I called it, is satisfied. Accordingly, for the power mereologist, the entangled components of the universe (construed as a vast entangled system) are fundamental powers or objects composed of fundamental powers. It is

important to recall that objects built of powers are also powers (see the section "Marmodoro's Moderate Approach"; Marmodoro (2017: 121–122) calls them 'substantial powers'). To be more precise, we should think of the third premise as including a disjunctive clause. We could reformulate it like this:

> (3*) The components of the entangled universe are all the compossible fundamental physical powers instantiated across the cosmos or powers constituted by all the compossible fundamental physical powers instantiated across the cosmos.

The choice between the two disjuncts depends on how one understands the entanglement relation. Textbook descriptions of the phenomenon are naturally read as suggesting that the entangled components are physical objects such as particles. But the distinctive modal connectedness displayed by entanglement components links physical properties, such as spin and momentum. Either way, since we are discussing a surprising implication of the power mereology view, the entangled entities should be taken to be fundamental powers or composite objects they build, which are themselves powers.

The last piece of the argument for the powerful cosmos, namely the *Marmodorean Link*, bridges the Marmodoro Condition to the other premises. The tricky part is establishing that the entangled universe displays the right sort of holistic dependence and re-individuation of parts satisfying the Marmodoro Condition. The defender of the argument could perform an evading strategy. They could claim that the argumentative burden of showing that the holistic dependence exhibited in entanglement does not suit the Marmodoro Condition lies on the shoulder of the opponent. While it would be preferable to avoid it, this move is consistent with Marmodoro's version of the power mereology view. And it is a more economical approach since it does not require us to adopt a disunified account of holistic dependence.

The re-individuation condition is more challenging to assess. Under the Marmodoro Condition, the parts of a metaphysically unified whole ceased to be discrete entities (see see the section "Marmodoro's Moderate Approach"; Marmodoro 2017: 120). In the context of this argument, this requirement implies that the entangled parts of the universe are not discrete items. Perhaps, it is intuitively easier to accept that the physical powers of a unified electron are re-individuated as its ways of being rather than to buy the same claim for the entangled particles of the universe. But such an intuitive resistance does not count against the possibility that the same sort of re-individuation extends to the physical powers of the universe, where the former are re-individuates as ways of being of the latter.[5]

So far, I have outlined the four premises of the argument for the powerful cosmos. Then, I have offered considerations in favour of their initial plausibility within the perspective of the power mereology view under study. Informally, we can state the argument like this. If we adopt the Mamorodoro Condition, and if we accept *Cosmic Entanglement*, *Holistic Dependence*, the *Power Mereology View*, and the *Marmodorean Link*, we reach the *prima facie* surprising conclusion that there is an object which is constituted by all the entangled powers instantiated across the universe: the powerful cosmos. The existence of such an object will strike many supporters of a moderate answer to the special power composition question as surprising and potentially distasteful. Recall that one of the motivations to embrace a moderate answer to the special power composition question is to rule out intuitively strange objects like *o* (namely, the object composed by the Glasgow charge and the Birmingham charge; see the section "Why Adopt a Moderate Approach to the Special Power-Composition Question?"). In a superficial sense, the powerful cosmos is a vastly bigger version of *o*. Contrary to this reaction, I end this chapter by arguing for the acceptance of the powerful cosmos as an unexpected yet beneficial consequence of Marmodoro's approach.

Why Embrace the Powerful Cosmos?

To begin with, I assure the reader of two important things. First, I do not claim that the power mereology view, on its own, *entails* the existence of the powerful cosmos. Second, the argument discussed in the previous section is openly controversial and apt to be the target of all sorts of responses. The power mereologist who wishes to preserve this view but block the powerful cosmos has three main options, which I sketch next.

First, against *Cosmic Entanglement*, someone could invoke physical considerations that cast doubts on the possibility of the universe forming a vast entangled system. For example, one could deny the existence of a wave function describing the entire quantum state of the universe. Alternatively, one could argue that collapse theories (encoding processes of entanglement) are inconsistent with *Cosmic Entanglement*.[6]

Second, against *Holistic Dependence*, someone could argue for adopting a different interpretation of the metaphysics of quantum entanglement relations. For instance, there are structuralist (e.g., McKenzie 2014) and coherentist views (e.g., Calosi and Morganti 2018) available on the market. On these approaches, as I understand them, the entangled components do not display the kind of holistic dependence that would satisfy the Marmodoro Condition. On structuralist views, the entangled components are asymmetrically dependent on the entanglement relation rather than the composite system. On coherentist approaches, there is a mutual dependency

between parts and whole. By contrast, holistic dependence demands mutual dependency between the parts, but these are asymmetrically dependent upon the whole.

Third, against the *Marmodorean Link*, one could design an objection undermining the re-individuation part of the Marmodoro Condition, showing that it is not satisfied by the universe and its entangled components.

Suppose, however, that you are on board with the power mereology view. Should you look for alternative ways to deny the ontological privilege of existence to the powerful cosmos? I do not think so. There are three main advantages you could claim over a power mereology view that does not embrace the powerful cosmos: one is metaphysical, another is empirical, and a further other is methodological.

Let us start with the metaphysical advantage. It seems to me that the acceptance of the powerful cosmos is preferable to the imposition of an arbitrary restriction on the kinds of objects the Marmodoro Condition can yield. The argument for the powerful cosmos does not rely on tweaking the idea that power composition occurs when collections of powers are holistically dependent and re-individuated in terms of the whole. The existence of the powerful cosmos is a metaphysical possibility consistent with the Marmodoro Condition *as is*, for nothing in its proposed formulation rules it out from the armchair. I argued that the actualisation of such a possibility follows from its conjunction with certain considerations from physical theory. We need some non-arbitrary justification for believing that a collection of powers satisfying the clauses of the Marmodoro Condition does not compose an object. As I suggested earlier, the power mereologist who endorses the Marmodoro Condition but wants to dodge the powerful cosmos has a better chance by targeting the peculiar interpretation of quantum mechanics and the metaphysics of the entanglement required by the other premises.

The second advantage is empirical. A view accepting the existence of the powerful cosmos is preferable to one facing the challenge of showing that the relevant scientific evidence is incorrect. Albeit I noted that rejecting the *Cosmic Entanglement* premise is a promising way to resist the argument, it should be stressed that empirical considerations support its truth. For example, the formalism of quantum theory appears to entail that the systems that evolve out of entanglement will become entangled again (Ney 2010: 229–230; Ismael and Schaffer 2020: 4150). Even on collapse approaches, systems do not completely evolve out of entanglement (this is sometimes called the 'problem of the tails of the wave function'). If it satisfies the Marmodoro Condition, the fleeting residual entanglement suffices for composing the powerful cosmos. Note that the argument discussed in the previous section can be temporally indexed. The existence of the powerful cosmos need not be a long-lasting affair. Consistently with the argument, it can occur and be confined to specific moments (namely all and

only those times in which all the compossible fundamental powers instantiated across the universe are entangled). That is, the powerful cosmos may have a short life span. Recall that what we are scrutinising here is its existence, not its persistence.

The last advantage is methodological. A view that welcomes the powerful cosmos need not impose further conditions on power-composition. It can happily maintain that the Marmodoro Condition answers the special power-composition question in a suitable way. By contrast, a view that rejects the powerful cosmos on the grounds of it being an unacceptable consequence of moderate power-composition implies that either some further requirement must be included in the Marmodoro Condition or that the circumstances under which power-composition occurs are completely different. Either option is problematic. Each of them leaves us with the task of identifying what these more appropriate conditions are. Of course, there may be independent reasons for rejecting or revising the Marmodoro Condition. Here my claim is that it is methodologically problematic to give up the Marmodoro Condition *because* its conjunction with some views about entanglement yields the existence of the powerful cosmos.

The advantages I outlined earlier are not conclusive and remain defeasible. However, they represent *prima facie* compelling reasons for believing that a Marmodorean view embracing the powerful cosmos is superior to one that does not. Therefore, moderate power mereologists who feel an intuitive resistance to the powerful cosmos should consider these benefits and go beyond the incredulous stare.

I conclude by paving the way for future work in this area. The *Cosmic Entanglement* premise is shared with *priority monism* – the view that the cosmos is an integrated whole which is prior to its parts (e.g., Schaffer 2010; Ismael and Schaffer 2020). This view has generated extensive literature (see Trgodon [2017] for a survey article on this topic, including useful references for objections and replies). The argument for the powerful cosmos does not commit the power mereologist to take it as the sole fundamental object, which is the distinctive claim of priority monism. Nor does the holistic dependence embedded in the Marmodoro Condition force us to think that the whole cosmos is prior its constituting powers. For instance, someone might argue that the relation of holistic dependence between the powerful parts and the whole they compose is naturally interpreted as these being equally fundamental. Yet we may wonder whether there are fruitful ways of combining priority monism and the mereology of powers. For example, we could investigate whether a powers-based approach to priority monism can claim some major advantages over its standard formulation. I cannot advance this project here. But I wish to end this chapter by stressing that priority monism and the discussed moderate answer to the special power-composition question share the idea that the

cosmos is a unified whole. With respect to this claim, such views are unexpected allies.[7]

Notes

1 One might ask a closely related question that could deserve the same name: In what circumstances do some powers compose some other power? I shall not discuss this question. See Mumford and Anjum (2011) for a compositional account of powers. See Bird (2016) and Pechlivanidi and Psillos (2020) for an assessment.

2 For an overview of these answers in the mereological case, see Van Inwagen (1990) – a *locus classicus* on this topic.

3 Even collapse views may recover something like the *Cosmic Entanglement* premise. For example, on Bohmian mechanics, the universal wave function encodes ways the universe could evolve including different sets of trajectories in which its particles can be guided. In Bohmiam mechanics, the universal wave functions representing the universe are not reducible to the states of its particles.

4 Other interpretations might support a similar claim. For instance, Ney (2021: 238–241) suggests that wave function realism ought to be committed to an analogous view.

5 Interestingly, the supporter of the argument for the powerful cosmos could draw from Ismael and Schaffer (2020) again. They take that the entangled parts are 'derivative aspects or fragments abstracted from a more fundamental whole' (2020: 4149). It seems to me that such a remark about abstraction fits nicely the idea of ways of being (cf. Levinson 1978).

6 For more details on how to develop these objections, see Calosi (2014), who argues that Schaffer's considerations in favour of the universe as a whole are not as straightforward as a first impression might suggest. See also Calosi (2018) for the connection between collapse theories and the universe as a vast entangled system.

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