

Cosmic Loops

Daniel Nolan, Draft

To appear in Bliss, R. and Priest, G. (eds) *Reality and Its Structure*. Oxford University Press

1. Introduction

Those of us interested in thinking about outré possibilities will be familiar with scenarios where there are large temporal and causal loops—for example, scenarios where time goes in a loop, so that e.g. a big crunch is immediately followed by the big bang. (I intend here a "one time around" loop, as opposed to the kind of eternal recurrence where there are infinitely many bang-to-crunch stretches, laid end to end.) In these scenarios, there are temporal loops and causal loops, but only ones that go all the way around the history of the universe. One example of these, of more than just metaphysical interest, is the closed temporal loop universe described by Gödel 1949, which appears to show that such temporal loops are allowed by Einstein's general theory of relativity.

Scenarios that are less familiar are ones where there are cosmic *grounding loops*: where the whole structure of grounding ensures that if you follow the chain around from any point, after enough steps you can arrive back where you started. In this paper I want to distinguish several interesting ways of thinking about such grounding loops, argue for the coherence of such models of grounding, consider whether they are metaphysically possible, and discuss how we might embed grounding structures which are *locally* irreflexive, anti-symmetric and transitive in worlds with such cosmic loops.

Any loop of grounding, of course, enables one in principle to trace it around and get back to the start. What is distinctive about *cosmic loops* is that they would require going around "the whole way", in a way that is analogous to the way that a cosmic temporal loop would require going through every other time to arrive back at the original time. The nice thing about times is that, when they are well behaved, they come with a complete ordering, but this is not true in general for objects that stand in grounding relationships. So it is a bit harder to say what "going around the whole way" would amount to for a grounding loop. It would be convenient if everything came with a grounding "level", as is supposed by some simple versions of the "layer cake" model of the special sciences: chemistry on top of physics, biology on top of chemistry, psychology on top of biology, and so on. Then we could insist that a cosmic loop of ground pass through all of the levels before coming back to the original one. Other

patterns in the world come with convenient layers that are less all-encompassing: the relation of part-to-whole can be used to order my fingernail as part of my finger, my finger as part of my hand, my hand as part of me. On its own, it will not serve as a convenient way of ordering everything, since there are distinct hierarchies of parts: my table leg is not part of my leg, nor vice versa. We would have a cosmic loop of part-to-whole if we started with one world (call it world 1) which had many atoms at one end of the part-whole hierarchy, and at the other end of the part-whole hierarchy a Universe that contained everything as parts, and considered another world, world 2, with the same pattern of part-to-whole except that the thing which was the Universe of world 1 was part of all the things which were atoms of world 1. In world 2, you could follow the chain of "part of" relations starting at the object which is world 1's Universe, right around to that very object again. World 2 would plausibly contain a cosmic grounding loop too, given the common assumption that wholes are grounded in their parts. (Perhaps world 2 would only be an impossible world, rather than a possible one: more on this question below.)

While I have hopefully said enough to get the idea of cosmic loops across, I have not yet provided a general definition. Rather than bogging down in a specification that avoids various tricky corner cases, I will present some exemplars which we may use as paradigms: especially since the issues that arise for my exemplars don't really depend on whether we have pinned down a unique concept of cosmic loops. One thing I do want to leave open, at least as far as the definition of "cosmic loop" goes, is that cosmic loops of ground might co-exist with shorter loops of ground. Again, time provides a useful analogy: even if the entire universe is a great temporal loop, say with a big bang at the "start" also serving as a big crunch at the "end", there may also be shorter loops created by time-travel machines or unusual spatio-temporal wormholes. Likewise, even if there are cosmic loops of ground that go "all the way around", there may also be short loops (e.g. the fact *that there are some facts* may ground itself¹). I also want to allow that a loop can be cosmic without bringing everything in a universe into its scope: a layer-cake universe might have several cosmic loops that contain a member from each layer, but do not share any members.

When we are considering cosmic loop scenarios, which loops will be grounding loops will depend on what kinds of relationships go along with relationships of grounding in those scenarios. I suppose that

1 See Fine 2010, though of course Fine himself is not tempted to allow that this fact grounds itself. It is instructive to see how difficult it is to *avoid* allowing it to be a ground of itself, if we make some other standard assumptions about grounding.

we could brutally stipulate grounding connections between different entities or facts, but it will be more natural, and more familiar, to think of grounding as going along with other relationships, such as the part-whole relation or the determinate-determinable relation. (Though there are of course debates to be had about which direction grounding goes even in these cases: part-to-whole, or whole-to-part, or sometimes one and sometimes the other, for example.)

Rival theories of grounding differ on whether grounding claims are most perspicuously to be expressed using a sentential or propositional connective, or a relational predicate. That is, if we wish to express a particular grounding connection to do with being scarlet and being red, whether $G(\text{Apple A is scarlet}, \text{Apple A is red})$, or $G(\text{A's scarletness}, \text{A's redness})$ best gets to the heart of the matter, assuming determinates ground determinables. I will talk as if grounding is a relation between objects in this paper, but this for convenience rather than to take a stand on this question. I will also not be making much of the distinction, often drawn, between full and partial ground: some cases I will discuss below are best seen as loops of full grounding and others only of partial grounding, but little relevant will hang on which are which. Finally, I will restrict my discussion to talk of singular grounding, instead of also talking about cases where some things *collectively* ground another (or some things are collectively grounded by a thing, or when some things collectively ground some others): this is not to take a stand on whether there is any irreducibly plural grounding, but again only because that distinction is not important for current purposes.

Warning: well-brought up readers of this paper are likely to have been taught that no sense can be made of talk of loops of grounding, cosmic or otherwise, so may find the cases to be discussed below repugnant to their grounding sensibilities. I would encourage those readers to do their best to get their heads around the cases, perhaps in the spirit of intellectual exploration of foreign conceptual landscapes. I will turn to discussing whether any of these examples are possible, coherent, or even conceivable in section 3.

2. Examples of Cosmic Loops

One of my favourite thought-experimental curiosities is a universe described by Rudy Rucker in his *Infinity and the Mind* (Rucker 1982 pp 33-34).

The Rucker Loop

What appears to be our entire universe is just a sub-atomic particle in a larger universe, which is but a sub-atomic particle in a yet larger 'universe', and so on ad infinitum. This is also true in the other direction: what seem to us now to be our smallest sub-atomic particles have the internal structure of entire 'universe', the sub-atomic particles of which are entire 'universes' themselves, and so on ad infinitum. What is distinctive about Rucker's thought is that this world also *loops*: go up through enough stages and you will arrive back at one of our sub-atomic particles, or go down through enough stages and you will reach our entire universe.

Rucker focuses on aspects of this imagined world like it having no absolute scale from smallest to largest (nothing is once-and-for-all the smallest or the largest, for example), and the prospect that it could nevertheless contain finitely many objects, despite e.g. everything being divisible without end. But the Rucker Loop suggests an interesting pattern of grounding, as well. It is often thought that a whole is *grounded* in its parts: and when there is a loop like this, that suggests that there is a loop in grounding. Even if we reversed this grounding connection, so that the parts of our cosmos are all grounded in the cosmos, we would get a loop of grounding—our cosmos grounded in the one 'above', grounded in the one 'above' that... grounded in our cosmos. Furthermore, we can suppose the loop (or the many loops) are all-encompassing—that no cosmos lacks a step in the loop, and that we have to go through a cosmos of each other level before arriving back at the cosmos we began with. Let us focus on one of the loops in this world, that begins and ends with our familiar cosmos. This loop is *cosmic* in the sense I have in mind for this paper.

Another cosmic loop of the part-to-whole relationship that has been discussed in the literature is one suggested by a story of Borges (Borges 2000, originally published 1949). In Borges's story, he describes an object, "the Aleph", which, on one reading, has everything in the universe as a proper part, even though it itself is a small globe found in a cellar in Buenos Aires. (On another reading, the Aleph merely provides a viewpoint on everything. Borges notes this reading within the story, suggesting that the *true* object that contains everything else in the universe may be a pillar in Cairo. I suppose it could be contested whether the part-to-whole loop goes *all* the way around mereological levels in this case, but Borges seems to describe at least a near-cosmic sized loop.) Sanford 1993 and Parsons unpublished both discuss Borges's Aleph, on the interpretation where the Aleph does contain everything as a part (and so looking into the Aleph, one even sees the Aleph itself within its basement, containing within itself the whole universe...). They both find it worthwhile to try to make coherent sense of it as a

possibility. Parsons further seems to suggest that if the Aleph is genuinely possible then the part-whole relationship is not anti-symmetric and transitive. I am not sure of Parsons's reasoning here, but perhaps he is using "anti-symmetric" in a way that a relation is anti-symmetric only if *necessarily* the relation does not relate an object to a distinct object and also vice versa.

Once the option of cosmic loops is noticed, it is easy to come up with other examples. Here are two examples that may be of use as thought experiments, or as pieces of speculative theology for those who are so inclined.

The Last Shall Be First

In this scenario, there is a god – let me label her TLSBF (for ‘the last shall be first’). TLSBF is both immanent and transcendent in the following way. (Leave aside any quibbles for now about whether this characterisation is strictly "immanence" or "transcendence" in the senses used in e.g. Christian theology.) TLSBF is within in the smallest places: let Her be a proper part of each spacetime point, or if you prefer let physical spacetime be gunky with no atomic physical parts, with Her being a proper part of every region. We could also directly specify that she is *located* within every point (or every gunky region), or perhaps her being parts of those points and regions will be enough, on some conceptions of location, to already guarantee this. Thus she is immanent in her world. (We may add that she is also part of every physical object too, if you wish.)

TLSBF is at the "bottom". But She is also at the "top". There is a region which has all other regions as sub-regions (the “universal region”), and TLBSF is located at that region. There is an entity which has everything in the universe as parts (as is standard in most theories of parts and wholes), and that universal entity is identical to TLSBF Herself. Let us explicitly include all the spacetime regions among her parts. Finally, let us stipulate that in this scenario, entities are grounded in their proper parts: so TLSBF is grounded in her parts, and there is a chain of grounds that lead from TLSBF to herself.

Let us restrict our attention to concrete objects, and leave aside questions about the grounding of abstract objects (if any) in our scenario. The TLSF scenario is incompatible with classical extensional mereology, which does not allow an object to be a proper part of itself (or indeed to stand in the ancestral of “proper part” to itself – since classical extensional mereology insists that “proper part” is

transitive, in ruling out one it rules out the other). Indeed, even much weaker mereologies may rule out this scenario unless we can find some other part of spacetime points to be co-parts of those points with TLSBF.

The One and the Cosmos: Emanating and Constituting

Another class of cosmic loop scenarios come into view if we pay attention to the option of saying that there are several kinds of grounding (whether this is because grounding is a genus which admits of various species, or because grounding, though unified, holds in different kinds of cases).

Consider a world which is in one respect rather neo-Platonist. The One is ultimate source of *emanation*, and this relationship passes through Soul, Wisdom, and other such luminaries, down through Forms, through the Intelligences that are to be found throughout the world, and finally to brute material entities, furthest from the One. Emanation goes with grounding, so that e.g. Wisdom is immediately grounded in the One, the Soul is immediately grounded in Wisdom... and the small material parts of intelligences are grounded in the intelligences they emanate from. (I don't suppose that this specific emanation structure matches that posited by any particular neo-Platonist, but you should be able to tinker with the emanation structure somewhat without affecting the point of the example.)

On the other hand, the smallest material parts make up the objects they belong to, those larger material objects constitute the Intelligences, the natures or activities of the Intelligences constitute the Forms, the Forms compose the Soul, which constitutes Wisdom, which is the Constitution of the One itself. Wholes are grounded in their parts, and the constituted by what constitutes it (at least in the scenario being described), so in this respect, grounding runs from the lowest to the highest.

This is not the same kind of loop as in the previous two cases. In the other two cases, the cosmic loop followed a circle: while we could pick our universe as the place to start and end in the Rucker Loop, it occupied no particularly privileged place, and while TLSBF served both as a proper part of spacetime points and as the Universe, we could follow the entire loop around by going from part to whole at each step. In this case, however, we have two grounding arrows facing in opposite directions: part-to-whole and constitution going in one direction, and emanating coming the other. To follow grounding around to get a loop requires going all the way up and then all the way down again.

A variant of this case can be imagined that would have a hybrid kind of loop. In this variant, the meanest of the material particles, furthest along the path of emanation from the One, each directly constitute the One and so directly and fully ground it. (Perhaps they do this by being simple, and therefore they are the ones that give rise to the One. Perhaps our hypothetical neo-Platonist constructing the account of this scenario has been meditating on the second half of Plato's *Parmenides*.) This loop connects most saliently at the One, which directly grounds Wisdom through emanation, and is directly grounded by each of the ones through constitution. While grounding goes in a circle in this variant, none of the relations that go along with grounding do: emanation and part-whole are one-way only, as is the "direct constitution" link from the material simples to the One.

Imaginative readers will probably be able to think of other interesting scenarios containing cosmic loops, but the three examples above should be enough to illustrate the idea and give some idea of the range of cosmic loop scenarios. The three cases presented are all cases taking entities to be grounded by other entities: those interested in expressing grounding using a sentential connective in the manner of Fine 2001 should be able to construct further scenarios where there are cosmic loops of such grounding without involving any cosmic loops of grounding between entities, but I have stretched our theoretical imaginations enough for one paper, so I will refrain from exploring any options of that sort here.

3. Cosmic Loops and Principles of Ground

Cosmic loops, on the face of it, conflict with some standard constraints on a theory of ground put forward in the literature. Ground is normally defined so that it is transitive, asymmetric and irreflexive, which would rule out loops: any loop would result, by transitivity, in something grounding itself. Furthermore, the correct principles of ground, whatever they are, are often thought to be necessary. (At least metaphysically necessary, though sometimes these principles are discussed as if they are partially *definitional* of ground, so may be intended to be analyticities as well.) Can cosmic loops be dismissed as impossibilities?

I would be tempted to argue that such loops are possible in some generous sense, since descriptions of

them are coherent.² But even if they are not possible at all (in any worldly or alethic sense, as opposed to being e.g. doxastic possibilities), I do not think this would justify an immediate dismissal of any discussion of cosmic loops. One main reason for this is that we are interested in deciding what to think about which principles of ground are correct, so even if alternatives to the true theory of ground are all metaphysical impossibilities, working out which theory of ground is correct may well require us to judge between alternatives to select the best one. In metaphysical inquiry, as elsewhere, dogmatic rejection of alternative theories as even being fit for discussion would be a terrible methodology, since it is often only by appreciating what alternative theoretical options there are to one's preferred views that we can work out whether our current opinions are better than alternatives, and so whether they are worthy of our continued belief.

Those uncongenial to these cosmic loop scenarios might doubt that they are even *coherent*. Anti-symmetry and transitivity are often put forward as if they are axiomatic of grounding, so some may suspect that it is a conceptual truth (or perhaps an analytic truth) that there are no loops of ground.³ Perhaps there is some concept of a grounding-like relation that, by conceptual stipulation, is anti-symmetric and transitive. But I doubt that such a concept is a very useful tool for investigating the world. One of the central aims of a theory of grounding, I would have thought, would be to discover what sorts of fundamental (and less-than-fundamental) metaphysical relationships obtain between entities (and/or what connections, more broadly speaking, hold between facts). If the important relationships in our world display the sort of loop structure suggested, a theory of ground should reflect that: it would be far less fruitful to declare that we have discovered there is no grounding, but there is merely grounding*, a relation that is found where we thought grounding might be, with all of the features of grounding except (e.g.) transitivity. Substantial metaphysical progress is not to be made by analytic stipulation, so we should select our conceptual tools with an eye to what can be used to illuminate our target of inquiry, rather than to try to bake in some of our favoured conclusions about that target in advance. Those who insist that according to *their* concept of grounding we can rule out cosmic loops of ground as incoherent are invited to deploy a concept better suited for substantive inquiry.

² They are possible in at least some of the ways I distinguish as candidates to be "metaphysical possibility" in Nolan 2011, though perhaps not in all.

³ A similar concern can be raised about whether it is a conceptual falsehood that the part-whole relation allows of loops: van Inwagen 1993, in response to Sanford's Aleph example (see p<4>, above), takes the line that the Aleph case involves a conceptual falsehood. I am tempted by a similar response in the case of part-whole as I am in the case of grounding: I would argue against the conceptual truth of e.g. asymmetry and transitivity of the part-whole relation, just as I argue against elevating principles of grounding to conceptual truths in the main text.

Some readers may find cases of cosmic loops so bizarre or outrageous that they may doubt that cosmic loops are even *conceivable*. (I intend to use "conceivable" in its ordinary sense, or something like its ordinary sense, and not in any of the stipulative senses introduced by philosophers such as Chalmers 2002.) As against this, it is hard to know what to offer in response beyond the plain fact that I and others do conceive of such scenarios—Rucker seems to have conceived of one of the scenarios above, I came up with two of the scenarios above myself, and I hopefully described them in enough detail to get across what is going on in them, at least to those not antecedently committed to finding such scenarios unintelligible. Perhaps some familiarity with neo-Platonist emanation will help for scenario 3. No doubt there will be those who suspect neo-Platonist emanation is unintelligible on its own: those people face an interesting psycho-historical challenge in explaining how hundreds of people over hundreds of years seemed to communicate and debate about emanation, without any of them conceiving of it.

Why would there be resistance to the claims that these scenarios are intelligible or imaginable or conceivable? One source of such resistance will be from people who think that conceivability is a good guide to possibility (Yablo 1993), and who also judge the scenarios I described to be impossible. Once one thinks that one's grasp of possibility is usually mediated by conceiving, it will be easy to pass from the thought that something seems impossible to the thought that it must be inconceivable. While being able to conceive of something often goes along with its possibility, trying to insist on too tight a connection either leaves one at the mercy of counterexamples to be found everywhere from philosophical theorising to Escher to the far reaches of speculative fiction, or encourages a dangerous attitude that the thing to do with an alternative one takes to be impossible is to try to convince oneself that one does not understand it. That would be an unhelpfully dogmatic move in many areas of science—imagine if opponents of the general theory of relativity had all reacted that way—and it seems no less dogmatic in philosophy.⁴

Another source of resistance will be less motivated by theory: I expect some people will find it difficult to understand the scenarios described, and not (necessarily) due to any defect in my presentation. On the face of it, one might have thought that people would take their own inability to

4 A third option would be to allow that many more things are possible than one might have thought, just because we can form some conception of them: see Mortensen 1989. But why engage in a large revision of our views of what is possible rather than a minor revision of a theory of the connection between conceivability and possibility?

conceive something as very weak evidence that it is inconceivable, especially when there are others who apparently conceive of the scenario under discussion. In some areas, this does seem to be people's response: those who find they cannot conceive of relativistic spacetime, for example, are often willing to defer to experts who claim to conceive of it, and so count relativistic spacetime as conceivable. But it is a curious fact that philosophers who have trouble conceiving of a scenario proposed by other philosophers are often keen to pronounce such scenarios inconceivable. (This often happens to me in conversation with philosophers when I claim to conceive things others claim they cannot, at least.)

To those inclined to take these cases to be inconceivable for this reason, let me remind them that familiarity with unusual scenarios can be mind-expanding, and to play with cosmic loop scenarios for a while before being confident that the scenarios are inconceivable, and not merely ruled out by principles that they endorse.

4. Recovering "local" irreflexivity, symmetry and transitivity in cosmic loops

A scenario can be a cosmic loop scenario even if grounding is closed under transitivity in it: these are cases where everything in a circle of ground grounds everything in that circle, including itself. But a more natural way to understand many of these circles of ground as being intransitive: while A grounds B which grounds C which grounds D which grounds E which... grounds A, these are not scenarios where A grounds itself or is somehow a *causa sui*. Or at the very least, this seems plausible for many of the entities in these loops: maybe TFSBL or The One are most naturally thought of as self-grounders, but entities in the "middle" of each loop, e.g. a given human hand, are not naturally thought of as self-grounders.

Even aside from this natural thought, it will be interesting to explore what the options are here for recovering *local* irreflexivity, asymmetry and transitivity in cosmic loop scenarios. That is, to what extent can we "save the appearances" and allow that *even if*, on some cosmic scale, there is a loop of grounding, we need not change our attitudes to the grounding relationships that hold e.g. between the cells and other components of my hand and my hand itself, or between the distribution of rain, clouds, and lightning, on the one hand, and a thunderstorm, on the other? Can things as we ordinarily take them to be embedded in a cosmos containing one or more cosmic loops at scales we are unfamiliar with? (Compare: in a universe with a unique big crunch that is immediately before its unique big bang, the direction of time might still be *locally* one-way, with no small loops letting people live

through 2014 before 2013.)

What would "local" mean in this context? One stab at characterising it would be to say that grounding is *locally* irreflexive, asymmetry and transitive iff when we restrict the domain of entities quantified over to some domain D , then for all x in D , x does not ground x , for all x and y in D , if x grounds y then y does not ground x , and for all x , y and z in D , if x grounds y and y grounds z , then x grounds z . Then we should insist on some restrictions on the appropriate D so that it is appropriately "local". We would be aiming to capture the idea that with a certain "distance", grounding behaves as if it is irreflexive, asymmetric and transitive, and cases where there are loops of ground only show up when we look at "long distances". The challenge then is to specify the relevant domains D that are "local" to each other, or alternatively to specify a "distance" so that any entities within that distance of a given object O count as belonging to the same domain D as O .

One way to pursue the former strategy would be to find some independent way of specifying domains and which objects share a common domain. Perhaps each of Rucker's "universes" could be its own domain, for example. One way to pursue the latter strategy would be to say that a domain D is local if there are no more than n steps of immediate grounding between any two members of D , for some suitably low n . This would require that we rely on a notion of "immediate ground", and find a way to apply it to the grounding chains we are concerned with. Sometimes it is easy to see what immediate ground would be: intuitively, the singleton of Socrates is immediately grounded in Socrates, but the singleton of the singleton of Socrates is plausibly *immediately* grounded only in the singleton of Socrates, and its grounding in Socrates is only mediate. In other cases, though, it is harder to draw the distinction. Am I immediately grounded in my cells, or only immediately grounded in objects such as my brain and liver, and only mediately (partially) grounded in my liver cells? Or am I immediately grounded in all my parts, down to the quarks and leptons? If we were to apply notions of immediate and mediate grounding in one's parts in the Rucker world, for example, we would at least want it to turn out that I was not *immediately* grounded in any of the galaxies that are parts of one of my electrons: though we may have to add stipulations to the original thought experiment if we wanted to guarantee this.

While an account of locality that appeals to immediate ground might capture a sufficient condition for a domain d to be of objects "local" to each other, it is probably too restrictive, in several ways. One is that there may well be cases where there is grounding, but no immediate grounding. This could be

because some forms of grounding do not lend themselves to an immediate/mediate distinction, and it could also be because there may well be cases where a kind of grounding is in general amenable to that distinction, but unusual cases defy categorisation. Consider this sort of structure: suppose that we have an infinite sequence where, for each finite stage, each stage after the first is immediately grounded in the stage below. Suppose now that this sequence has a first "infinite" member: if we were ordering the stages by ordinals, we would assign that stage the ordinal ω . That stage may be plausibly grounded in the stages that came before, but not plausibly *immediately* grounded in any of them: there is no stage "immediately before" it in the series. One might even think the ordinals themselves are like this. It is more usual to think that ordinals are immediately grounded in *all* the ordinals that precede them (if "member of" corresponds to immediate grounding, and we accept the von Neumann definition of ordinals), but orthodoxy here is not compulsory.

Another challenge the particular account of "locality" offered here faces, even apart from any concerns about its relying on a notion of immediate ground, is that it does not yet rule out gerrymandered "neighbourhoods". A selection of a handful of things that do not stand in any chains of grounding to each other will count as a "neighbourhood": one of my electrons, the singleton of Socrates, and Abraham Lincoln's last thought is an example of a 3-membered domain that we may want to rule out as one of the relevant domains D that we are defining locality over. On the other hand, we do not want to insist that every member of D either grounds, or is grounded by, every other: if we want these domains to include ones we typically think about, we might want to include me, and all of my quarks and leptons, as well as intermediate parts, in a single D , without insisting that each of my electrons either grounds, or is grounded by, each of the others.

I will resist the temptation to go down the rabbit-hole of developing and critiquing different criteria we might have for selecting a domain D , and ensuring that each domain shares a "locality" in an intuitive sense. Instead, I will turn to a different challenge. To ensure that grounding can be "locally" irreflexive and asymmetric, transitivity must fail somewhere in the cosmic loop—otherwise everything in the loop will ground itself, for example, since we will be able to go from a thing back to itself by steps of grounding. (A failure of irreflexivity is automatically also a failure of asymmetry). The challenge then is to say how grounding could fail to be transitive around the whole loop while being *locally* transitive, especially if we desire that it is locally transitive everywhere: otherwise enough applications of local transitivity might take us around the whole loop, provided the "locations" overlap.

There are a few ways to try to satisfy the demand for local transitivity in the face of this need for a counterexample to transitivity somewhere in the loop. The most conservative way would be to abandon the demand for local transitivity *everywhere*: perhaps there are no counterexamples to transitivity in parts of the cosmos we are familiar with, but the counterexamples occur somewhere else. A version of this strategy that would work with case 3 would be to insist that grounding per se is not transitive, but only the species of grounding are (in case 3, emanation and constitution). In the second variant of case 3, for example, the obvious point where the counterexample to transitivity of grounding would occur is from the ones to the One and then to Wisdom, since the ones constitute The One but Wisdom only stands in the emanation relation from The One.

Suppose we wanted to get closer to the idea that grounding was *always* locally transitive. We could tinker with our account of what entities are "local" to which, so counterexamples to transitivity only occur when entities do not share a locality (e.g. if there were clear borders between cosmoi in the Rucker loop, perhaps two entities would need to share a cosmos to be local to each other). Or we could wheel out more high-powered philosophical resources. One traditional area where philosophers have struggled with the conflicting desires to have a local inheritance principle that fails over longer distances is in dealing with the paradoxes of vagueness: in the sorites paradox, for example, we would like to hold onto the idea that subtracting one grain of sand from a heap always leaves a heap, but also to the idea that subtraction of enough grains of sand turns a heap to a non-heap. Likewise, if we want local transitivity without full-strength transitivity, we would like the ground of a ground to always be a ground, but there to be some number of iterations of the immediate grounding relation that takes us from a ground to a non-ground, with it being vague where the series breaks down. Perhaps resources developed to help with the sorites could be employed to help with the marriage of local transitivity to a failure of full-strength transitivity?

The literature on ways to resist the sorites paradox is vast, and so I will not try to list all the available options here. Options include taking the transitivity principle to have no *false* instances, but some instances that fail to be true (as with supervaluationist approaches, for example); or to think that some instances of the transitivity principle are *almost* fully true, and perhaps all steps involving immediate grounding are true enough to assert, though the slow leakage of truth from antecedent to consequent in each instance allows us to have a series of steps of x_1 immediately grounding x_2 , x_2 immediately grounding x_3 etc. without it being at all true that x_1 grounds x_{1000} (as in fuzzy-logical treatments of vagueness). Both of these approaches compromise the (full) truth of the general transitivity principle,

while salvaging the absence of some kinds of counter-examples—there will be no particular "break" in the chain to be identified.

Other, slightly more exotic, options, would be to retain the full truth of the transitivity principle but weaken our logical resources so that we cannot validly apply it multiple times: just as we cannot validly reach the conclusion that a single grain of sand is a heap, we will not be able to validly reach the conclusion that x_1 grounds x_{1000} , even if x_1 grounds x_2 , and x_2 grounds x_3 , and grounding is transitive. Ways of doing something similar in the case of the sorites include the contraction-free approach explored by Slaney 1988 and Restall 1994 ch 8, and the intransitivity-of-validity approach explored by Cobreros et. al 2012, among others. Yet another option would be to adopt an approach that rendered at least the material version of transitivity true while making it unsuitable for use in inferring the consequent from the antecedent, by analogy with the subvaluational approach to vagueness explored in Hyde 1997. I am inclined to think that any commitment to transitivity of grounding would not be strong enough to motivate these sort of logical modifications to preserve local transitivity of grounding: but those already keen on these resources, perhaps to preserve tolerance principles in vague cases, may find it appealing to treat apparent failure of transitivity in cosmic loop cases with similar resources.

Armed with an understanding of how to ensure local transitivity and asymmetry without global transitivity in cases of loops of grounding (whichever understanding we might adopt), we can apply the same resources to other relations of interest, including those that appear to underpin grounding relationships. One thing that makes Rucker loops so mind-bending, for example, is that they challenge our assumptions about the part-whole relationship: that I, for example, could be a proper-part of a proper-part of a proper-part of... myself. That would be impossible were the proper-part relation both asymmetric and transitive. However, one thing that makes the case less mind-bending than short loops of the proper-parthood relation (e.g. just stipulating that A is a proper part of B and B is a proper part of A) is that in a Rucker world with local transitivity and asymmetry the relation of proper-part to whole would behave just as it actually does in cases we are familiar with: I am part of the Milky Way Galaxy, but the Milky Way Galaxy is not part of me. This is not the only way to conceive of a Rucker loop, of course: another way would be to conceive of the Milky Way as being one of my parts, but just much further down a natural chain of part-to-whole than one might have thought. But at least the option of retaining local transitivity and asymmetry gives us one way to think of the Rucker loop scenario as being one in which our ordinary particular judgements about what is part of what do not need to be

revised.

Similar devices could also be deployed if we wished to claim there was local *near*-transitivity, *near*-asymmetry and *near*-irreflexivity of ground and of other notions. After all, a number of authors have wanted to motivate exceptions to each of these principles independently of anything to do with very long chains of ground. See, for example, Jenkins 2011 on reflexivity, Barnes (manuscript), on symmetry, Schaffer 2012 on transitivity, and Bliss 2011 on all three, as well as many of the other papers in this volume. One, perhaps inelegant, way to modify local transitivity to local near-transitivity, for example, would be to say that *except for such-and-such cases* grounding is locally transitive within a domain D . A more elegant way to specify local near-transitivity would be to have a positive story about when, for entities among a given D , it is the case that when x grounds y and y grounds z , x also grounds z . Even more elegant would be such a principle that applies to all "local" domains D at once, rather than separately specified principles about each D individually.

Suppose we do secure local transitivity (or something close to it) without requiring transitivity *tout court*. What advantages could that offer a theory that postulated a cosmic loop? One advantage is that grounding relationships would be more selective. A grounding loop which is transitive requires everything in the loop to ground everything else in that loop, which might sometimes seem counterintuitive: even if both the Milky Way and an electron in it are part of the one Rucker loop, intuitively the electron partly grounds the Milky Way and not the other way around. Perhaps we should think that cosmic loops where grounding is transitive, and so everything in a loop grounds everything else in that loop, are *also* conceivable and maybe possible: but it is natural to think that not all grounding loops are like this, and perhaps not the ones that most naturally come to mind when presented with cases like those given in section 2.

Another advantage follows if we antecedently thought that instances of grounding we are familiar with appear to never relate entities to themselves, relate in an asymmetric "direction", and at least appear transitive. While there are many papers in this volume that will argue that even grounding we are familiar with need not always be like this, we retain the option of leaving our theory of the grounding relationships between familiar entities as being traditional, while accepting (or leaving open the possibility) that there are cosmic grounding loops outside our familiar domain. The options for preserving local transitivity will also be valuable, apart from any doctrines about grounding, when dealing with other metaphysical relationships we are tempted to think are asymmetric and transitive,

such as the relation of part-to-whole. The Rucker loop, for example promises to shed light on the conceivable, and perhaps possible, options for mereology as well as for grounding.

Those suggesting philosophical innovations, or even scepticism about received wisdom, are often under pressure to "save the phenomena": to explain why it seemed that the old orthodoxy was right, or why we can often rely on generalisations or inferences supported by the old orthodoxy. For example, the nihilist about tables and chairs owes us a story of our apparent success in home decoration and lunch preparation, or the dialethist logician owes us a story about why classical mathematics seems to have been such a success in the twentieth century while apparently relying on classical logic. One way to "save the phenomena" is to corral exceptions to previous orthodoxies to cases that are relatively unusual: classical physics can be used to build bridges or aim cannon, because e.g. moving objects do not get appreciably more massive as they speed up until they get to speeds close to the speed of light. Recovering "local" transitivity, asymmetry and irreflexivity for grounding is one way to show how the exceptions to those principles do not show up in the cases we were most familiar with.

Grounding loops will appear exotic to many, but if a theory postulating a grounding loop only offends our intuitions in cases far removed from those with which we are familiar, then we may not wish to trust our intuitions very far about those cases. The comparison with theorising about causation may be instructive: while we are, in my view, properly reluctant to abandon the view that rock throwings sometimes cause window breakings or that stockmarket crashes cause unemployment, we are much less certain about our ordinary causal generalisations and intuitions when considering cases like quantum mechanical phenomena or the big bang. And rightly so: exotic phenomena might behave exotically. To work out whether there are cosmic loops of ground, or of part-whole, or other such relations, we would do well not to just trust our off-the-cuff generalisations but to carefully investigate cases outside familiar ones.

5. Conclusion

Cosmic loops are of intrinsic interest: thinking about them can satisfy the same urges to grapple with the unfamiliar which are satisfied by various sorts of speculative fiction, from science fiction to the stories of Borges. Metaphysical fiction is a genre in its infancy, but a promising one for all that.

I have argued that thinking about cosmic loops serves several more academic purposes, however. They

demonstrate, that we can make sense of loops of ground in a different way from the usual examples of loops achieved through only a few steps, and the conceivability and perhaps possibility of them are supported in ways different from other arguments I know of to support failures of asymmetry and transitivity. This should give us additional reason, were additional reason needed, to admit the conceivability, and consider seriously the possibility, that grounding need not be transitive (and to a lesser extent, reason to take non-symmetry seriously, if we think that some cosmic loops of ground are not counterexamples to transitivity). Finally, through exploring options for recovering local transitivity (and so local asymmetry and irreflexivity, should we want them), we can see that confidence about grounding relations between familiar items should not lead us to overconfidence about general principles of ground, no more than experiencing the local asymmetry of the direction of time should lead us to assert dogmatically that cosmic temporal loops are impossible.

Those who want to reject the possibility of cosmic loops, let alone those who reject the coherence of them, would be well served to defend the principles they think rule out such loops, rather than just taking those principles to be obvious or analytic. And this applies just as much to cosmic loops of part-to-whole, or cosmic loops of any other relation, as it does to cosmic loops of grounding. Metaphysics, with its hope to be a completely general investigation of what there is, should be particularly wary of the perils of overgeneralisation.⁵

References

Barnes, E. manuscript. "Symmetric Dependence"

Bliss, R. 2011. *Against Metaphysical Foundationalism*. PhD thesis, University of Melbourne.

Borges, J.L. 2000. *The Aleph and Other Stories*. London: Penguin

Chalmers, D. 2002. "Does Conceivability Entail Possibility?" in Gendler, T. and Hawthorne, J. *Conceivability and Possibility*. Oxford: Oxford University Press pp 145-200

Cobrerros, P., Egré, P., Ripley, D., van Rooij, R. forthcoming "Vagueness, Truth and Permissive

⁵ Thanks to Sara Bernstein, Ross Cameron, Alex Sandgren and two anonymous referees for feedback.

Consequence" in Achourioti, T., Galinon, H., Fujimoto, K. and Martinez-Fernandez, J. (eds) *Unifying the Philosophy of Truth*. Dordrecht: Springer

Fine, K. 2001. "The Question of Realism". *Philosopher's Imprint* 1: 1-30

Fine, K. 2010. "Some Puzzles of Ground". *Notre Dame Journal of Formal Logic* 51.1: 97-118

Gödel, K. 1949. "A Remark About the Relationship Between Relativity Theory and Idealistic Philosophy" in Schlipp, P.A. (ed) *Albert Einstein: Philosophical Scientist*. Library of the Living Philosophers, La Salle, Ill: Open Court Press. pp 555-562

Hyde, D. 1997. "From Heaps of Gaps to Heaps of Gluts". *Mind* 106.424: 641-660

Jenkins, C.S. 2011. "Is Metaphysical Grounding Irreflexive?" *The Monist* 94.2: 267-76

Mortensen, C. 1989. "Anything is Possible". *Erkenntnis* 30.3: 319-337

Nolan, D. 2011. "The Extent of Metaphysical Necessity". *Philosophical Perspectives* 25.1: 313-339

Parsons, J. unpublished. "The Earth and the Aleph". <http://www.joshparsons.net/draft/aleph/> Accessed 16 January 2016.

Restall, G. 1994. *On Logics Without Contraction*. PhD Thesis, University of Queensland.

Rucker, R. 1982. *Infinity and the Mind*. London: Paladin Books.

Sanford, D. "The Problem of the Many, Many Composition Questions, and Naive Mereology". *Nous* 27.2: 219-228

Schaffer, J. 2012. "Grounding, Transitivity and Contrastivity" in Correia, F. and Schnieder, B. (eds) 2012. *Grounding and Explanation*. Cambridge: Cambridge University Press, pp 122-38

Slaney, J. K. 1988. "Vagueness Revisited". Australian National University, Automated Reasoning

Project Technical Report, TR-ARP-15/88

van Inwagen, P. 1993. "Naive Mereology, Admissible Valuations, and Other Matters". *Noûs* 27.2: 229–234.

Yablo. S. 1993. "Is Conceivability a Guide to Possibility?". *Philosophy and Phenomenological Research* 53: 1-42