Review of Gordon Belot, *Geometric Possibility*
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Jill North

This is a neat little book (138 pages without appendices, under 200 with). It focuses on one aspect of the debate between substantivalism and relationalism about space. (Belot discusses things in terms of space rather than spacetime, explaining this choice at the end.) As Belot convincingly argues in chapter 2, the relationalist should be a modal relationalist, positing, in the spatial facts about a world, not just the actual configurations of material objects but the possible ones too. Others have argued that the relationalist should go modal, without tackling the difficult question of exactly what kind of modality is involved. *Geometric Possibility* is a sustained look at what this kind of modality could be. Belot explores three different accounts of this notion, which fall in line with three different accounts of laws. The result is a book that has interesting things to say not only about modal relationalism and different spatial geometries but also about laws of nature, varieties of modality, and ontology generally.

The introduction is primarily stage-setting, but it also makes an important point: the relationalist, like the substantivalist, can be a realist in the sense of "attribut[ing] to reality a determinate spatial structure" (1). For the relationalist, this is the structure of the (possible and actual) spatial relations among material objects; for the substantivalist, this is the structure of relations among the parts of space.

This yields a somewhat different understanding of the debate from what's typically given: "Relationalists and substantivalists can agree...that space is a thing of some sort and that it has some geometric structure. Their disagreement concerns the nature of the existence of space" (2). I largely agree. However, Belot doesn't want to frame the dispute as

about ontology, whether space *exists*, since he thinks this blurs the realism/antirealism distinction, and here we part company. I'd say this instead. Both the relationalist and substantivalist can be realists about spatial structure, as Belot notes. Still, they do disagree about whether space exists: their dispute is about what ontology underlies that spatial structure. The substantivalist says this structure inheres in a physical space. The relationalist denies that there exists any such physical space, saying this is simply a structure of relations among material objects. To me, this best captures the characteristic difference between the two views, while acknowledging that the relationalist can be a kind of spatial realist.

In chapter 1, Belot explores the question of which mathematical structures correspond to the spatial geometries of possible worlds. He begins with the reasonable premise that Euclidean space is one possible structure and suggests that generalizations of this correspond to other possibilities. He concludes, "All possible spatial geometries are represented by metric spaces" (31), spaces with a natural notion of distance, and he describes a variety of these. Many of the examples pop up later in the book, though some readers may not be as interested in the mathematical details until after reading later chapters. Particularly interesting here is Belot's objection to the often tacit assumption that Riemannian manifolds give us all the possible spatial structures. Limiting possible spaces to these structures violates a natural principle of plenitude since the space of Riemannian manifolds is "gappy."

Chapter 2 contains Belot's arguments that the relationalist should be a modal relationalist. The overarching idea is that there are even quite simple spatial structures we surely wish to countenance, yet which the nonmodal relationalist is unable to capture. Modal relationalism provides the truth conditions needed for the nonsubstantivalist to make sense of claims about the spatial geometry of a world.

At the end of the chapter, Belot shows that three initially plausible conditions on geometric possibility cannot (given one further natural assumption) be jointly satisfied. In following chapters, he evaluates three accounts of geometric possibility, each rejecting one of these conditions. Chapter 3 discusses Huggett's (2006) relationalism, which goes naturally with a best-system account of both laws and geometric possibility. Chapter 4 discusses primitivism about geometric possibility, analogous to

primitivism about laws. Chapter 5 discusses a view of geometric possibility analogous to necessitarianism about laws.

The conclusion sums up and discusses the (often obscure) relationship between relationalism about ontology and about motion. Belot concludes that either primitivism or necessitarianism is most plausible, without taking a firm stand on either one, although he most likes the latter. Either way, the relationalist requires a new notion of geometric possibility, which is distinct from physical possibility and may not, surprisingly, be grounded in the ordinary geometric properties instantiated at a world (such as the distance relations among material objects).

Finally, there are five appendices. In one, Belot argues that the simplicity of an ontology (though a relationalist, he seems to admit that substantivalism is simpler in this way) isn't evidence that it is true.

I'll end with three general thoughts differing from Belot's. (There is much more worth discussing.) First, it seems to me that there's a more straightforward argument that modal relationalism is the most viable form of relationalism. The relationalist (as well as the substantivalist) should posit the spacetime structure needed for the laws—in accord with a generally accepted methodological principle—and the actually instantiated spatiotemporal relations won't, in general, suffice to fix or ground that structure.

Second, I wonder whether modal relationalism requires a sui generis kind of modality. In Chapter 2, Belot gives two arguments against the view that this is just physical possibility. First, there are generally different global spatial structures allowed by a set of laws; for example, both infinite Euclidean space and a three-torus are consistent with Maxwell's equations and the Lorentz force law. So at any world allowed by these laws, it's physically possible for there to be an infinite array of material particles—that is, for some particles to be infinitely far apart—even though this isn't geometrically possible at the toroidal worlds. Second, the relationalist needs a distinct kind of modality to accommodate claims about certain spatial structures, for example, that space can be infinite even if it's physically impossible for matter to travel beyond a finite region.

Though reasonable, these arguments aren't, I think, decisive. Against the second, the relationalist (and even the substantivalist) could deny that such a scenario makes sense. If material objects cannot move beyond a

certain region, perhaps that region is all there is to the spatial structure of the world—especially if the laws say it's impossible for particles to travel to infinity, and one thinks the laws indicate a world's spatial structure.

Against the first, suppose that physical possibility is consistency with the laws (the details depend on one's view of laws). Generally, a set of laws will require a certain spacetime structure. For example, the laws of special relativity require a Minkowski spacetime: other spacetime metrics aren't physically possible. Even so, there may be other differences in (spatial or spacetime) structure allowed by the laws, such as differences in global spatial topology. Now consider all the worlds consistent with some laws. Relative to any one of these worlds, the others are physically possible in that they're allowed by the world's laws, even though some won't be (physically) possible once we add further physical facts about the given world, such as the global topology, as constraints. Thus, relative to Belot's toroidal world, there's a sense in which an infinite array of particles is physically possible: there are other worlds consistent with the laws that have such arrays. But there's also a sense in which this isn't physically possible since within the subset of possible worlds whose space is toroidal, there can't—according to the spatial geometry and the laws that allow that structure—be infinite arrays of particles. Perhaps there is simply a broader and narrower sense of physical possibility in play here, depending on how much one specifies about a world, rather than a distinct kind of possibility. Compare: specifying a world's initial conditions further constrains the behaviors seen as physically possible relative to the world, yet we don't infer a distinct kind of "initial-conditions possibility." Maybe what Belot calls geometric possibility isn't a new, sui generis modality but a kind of physical possibility—what's possible according to the laws, which themselves constrain the geometry of space(time). (Perhaps in the end there is no way for the relationalist to make this work, in which case this is more of an argument for substantivalism than an objection to the idea that the relationalist needs a new kind of possibility.)

Third, Belot objects to a Quinean view that in ontological investigations, we should think the simplest theory likely to be true, though he allows for this in scientific inquiry. If one takes as a starting point that ontological inquiry is continuous with scientific inquiry, however, one will thereby think their methodologies alike, and Belot's arguments to

the contrary will be nonstarters. Belot further argues that in ontological inquiry, simplicity isn't evidence of truth because it isn't sensitive to truth: we'd have the same evidence, including the same philosophical arguments, in a world with a given spatial structure regardless of whether space is substantival or relational there. However, I'm not sure that we need more than the actual track record of the methodological principles we use (including parsimony principles), which we think have generally been successful—even if we can't show that they reliably track truth. Indeed, even if relationalism and substantivalism are each compatible with the evidence that can be obtained by a world's inhabitants, I think this just shows that we can be wrong in our inference to a given ontology, not that we can't still have good reason to infer the simpler ontology.

Altogether, this is a very good book, which anyone interested in spacetime ontology and related issues in philosophy of physics, philosophy of science, and metaphysics should read.

References

Huggett, Nick (2006). "The Regularity Account of Relational Spacetime." *Mind* 115, 41–73.