Spacetime Redescription via the ISE Methodology

What if it were possible to remove and replace the topological underpinnings of our spacetime theories just as easily as one can switch between different coordinate systems? Grimmer (2023) claims this is possible by using his recently introduced ISE Methodology. In this talk, I will assess (and ultimately validate) this claim before discussing its philosophical consequences. Allow me to first rehearse the impact that other kinds of re-description have had in both physics and the philosophy of physics.

In physics, a capacity to freely redescribe our theories in various ways is often pragmatically useful. Consider our ability to switch in between different coordinate systems or to re-axiomatize a theory stated in first-order logic. Philosophically, such capacities for redescription are useful as they shed light on the age-old question of scientific realism: Which aspects of our best physical theories should we take to be reflecting real stuff out there in the world (as opposed to merely being an artifact of our representational techniques)? Allow me to briefly review the role that our capacities for coordinate, law-like, and geometric redescription have played in helping us address this question.

As a first example, consider the role that our capacity for logical re-axiomization plays in supporting a broadly Humean view of the laws of nature. Suppose that one is presented with an empirically successful physical theory which is stated in first-order logic in terms of a handful of relatively simple axioms. Several candidates for ontological commitment may immediately jump out at us: the elements of this theory's domain (a la Quine), the properties which are ascribed to those elements (e.g., understood as forms or universals), and finally the axioms themselves (e.g., understood as metaphysically substantial laws of nature which *govern* the world).

Notice, however, that one can freely re-axiomatize this theory without changing any of its logical consequences. In light of this, one might grow suspicious of any ontological status being granted to the laws of nature. Indeed, given our capacity for law-like redescription one finds some motivation to metaphysically deflate the laws of nature and to focus instead on the theory's law-independent content (e.g., the Humean mosaic, or more generally, the dynamical behavior of matter). From this perspective, our theory's original laws of nature reflect nothing metaphysically substantial in the world, rather they are just one particularly nice way (among others) of codifying the dynamical behavior of matter.

As a second example, suppose that one is presented with an empirically successful spacetime theory which takes a particularly simple form in some fixed coordinate system, e.g., inertial coordinates. Coordinates (more so than law-like axioms) are clearly poor candidates for ontological commitment; They are more obviously a representational device which we project onto the world. As any good physicist knows, an inelegant choice of coordinates can lead to coordinate artifacts which simultaneously hide key bits of physics from view and produce illusory singularities. Fortunately, these issues can be overcome with a more apt choice of coordinates.

Better yet, one can remove all coordinate artifacts by adopting a stylistic commitment to general covariance (i.e., a commitment to coordinate-independent formulations of physics). Indeed, one can always reformulate one's spacetime theories in the coordinate-free language of differential geometry. Obviously, our theory's original coordinate system reflects nothing metaphysically substantial in the world, rather it was just one particularly nice way (among others) of codifying the dynamical behavior of matter.

As a bonus, reformulating one's spacetime theories in a coordinate-free way has a tendency to reveal their previously hidden geometric structures (e.g., η^{ab} in special relativity). Getting rid of these representational artifacts has revealed some tempting new candidates for ontological commitment. One might, of course, try to resist this temptation by developing some geometric redescription techniques in order to metaphysically deflate these geometric structures (just as the laws and coordinates were above). See, for instance, the work of Huggett (2006) on Regularity Relationism. Any such geometric redescription tools can be employed in support of a dynamics-first view of geometry: The fixed geometric structures which appear in our theories (e.g., η_{ab} in special relativity) reflect nothing metaphysically substantial in the world, rather they are just one particularly nice way (among others) of codifying the dynamical behavior of matter. As Norton (2008) notes, however, deflating a theory's geometric structures in this way still leaves its topological structure (i.e., the spacetime manifold itself, $\mathcal{M}$) intact as a serious candidate for ontological commitment.

In light of Norton's complaint, it is natural to wonder whether the dynamics-first view of geometry can be extended to cover the topological structures which appear ubiquitously in our spacetime theories. As the above discussion has revealed, in a variety of contexts (e.g., laws, coordinates, geometry) our capacity for redescription impinges directly upon metaphysical debates regarding what ontological commitments one ought to draw from our best physical theories. Putting these points together, one way to achieve such a dynamics-first view of topology would be to develop some powerful techniques for topological redescription (ideally something on par with our capacity for coordinate redescription and re-axiomization). Grimmer (2023) claims to have done exactly this with his recently introduced ISE Methodology. The purpose of this paper is to assess (and ultimately validate) this claim.

This paper will assess the power and scope of the topological redescription techniques offered to us by the ISE Methodology. Roughly put, ISE-related spacetime theories differ merely regarding which smooth transformations of the theory's states they regard as spatiotemporal. As I will discuss, both scope of spacetime theories to which the ISE Methodology is applicable is extremely broad; It includes every spacetime theory which meets a very weak spacetime-kinematic compatibility condition. Next, I will prove that ISE-relatedness is an equivalence relation over such theories and give an exact characterization of its equivalence classes. As I will prove, two spacetime theories are ISE-equivalent if and only if 1) they both have at least a minimal level of spacetime-kinematic compatibility, and 2) there is a certain kind of dynamics-preserving isomorphism between their kinematic structures.

Hence, the ISE Methodology allows us to access effectively every possible spacetime framing of a given theory's kinematical and dynamical content, bounded only by a weak spacetime-kinematic compatibility condition. The existence of such a powerful topological redescription technique casts doubt upon any metaphysically heavy interpretations of the spacetime manifold. Rather, it suggests that space and time ought to be understood (along roughly Kantian lines) as being a feature of how we *represent* the world. While these results originated from a metaphysical enquiry, they have a clear implications for current physics research. Since the spacetime manifold is merely a representational device, we do not need to quantize it; Our efforts to quantize spacetime should be redirected towards quantizing gravity.

References

Grimmer, D. (2023). In search of new spacetimes: Spacetime non-fundamentality even for well-established physics.
URL: *https://arxiv.org/abs/2303.04130*

Huggett, N. (2006). The regularity account of relational spacetime, *Mind* **115**(457): 41–73.

Norton, J. D. (2008). Why constructive relativity fails, *The British Journal for the Philosophy of Science* **59**(4): 821–834.