Objective Description in Physics*

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Scientists and philosophers aren't afraid to talk about "good theories" or "bad theories". A theory might be good because it is simple, empirically adequate, or consistent with other well-established theories. Conversely, there are many ways in which a theory can be bad, e.g. if it is vague, inconsistent, needlessly complex, or has a bloated ontology. Regardless of what one thinks about these particular characteristics, there is no doubt that judgments of this kind play an important role in practical decisions about how to do science. For example, if one judges a theory to be bad (as, e.g., Einstein and Bell judged quantum mechanics to be), then one has prima facie reason to look for another theory.

Philosophers have been less prone to judge scientists or scientific practices as good or bad. There are some exceptions to this rule, especially in the aftermath of the practice turn in philosophy of science. Nonetheless, large swaths of the literature are devoted to evaluating the abstract products of scientific theorizing.

One interesting borderline case is the virtue of objectivity, or of describing a situation objectively.[1] Is it people who can be objective? Or does objectivity attach primarily to abstract things such as theories or descriptions? For example, a description such as "Brussels sprouts taste bad" might be considered to lack objectivity, since we tend to think that there are no objective facts about taste. But does that statement lack objectivity in itself, or is it just that a person who asserts that statement is not being objective? These questions are not easy to settle, and I won't try to attack them head on.

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[1]See (Douglas, 2004) for a discussion of the multifaceted nature of the virtue of objectivity.

What I will be concerned with is how the ideal of "objective description" can and should function to steer scientific practice. In particular, I identify two contrasting ideals of what physics should deliver in terms of objective descriptions of the world:

- (Einstein) Physics aims to provide a description of the world as it is in itself.
- (Bohr) Physics aims to enable humans to make correct descriptions and to communicate these descriptions with each other.

Einstein's ideal is shared by many philosophers, both historical and contemporary: Spinoza, Hegel, Bernard Williams, and Ted Sider, among many others. Einstein's ideal is also tacitly assumed by many metaphysicians in their search for "artifact free representations", and by many philosophers of physics in their search for "coordinate-free" or "intrinsic" formulations of theories. I will argue, however, that the ideal of describing things as they are in themselves is incoherent. I will instead advocate an ideal of objectivity that is more like Bohr's. What's more, I argue that this ideal does *not* involve a retreat from the belief in a shared objective reality, which is expressed in terms of objective standards for correct translation between descriptions.

1 Einstein's ideal

To a first approximation, Einstein believed that the aim of physics is to "know God's thoughts", or to use a similar metaphor, to describe the world from a god's eye view. Einstein thought that quantum mechanics doesn't supply such a god's eye view, and on that basis, he judged it to be a bad theory. In contrast, Bohr believed that the aim of physics is to harmonize the experiences of different finite observers, and he thought that quantum mechanics is a good theory precisely because it does that. So what might seem to be an abstruse philosophical question — what is an objective description? — had a decisive influence on the choices that Bohr and Einstein made in their scientific careers.

To my knowledge, Einstein never gives an explicit account of his understanding of objectivity. For example, he never explicitly says "the goal of physics is a god's eye view description of reality". So it would be unfair of me to turn Einstein's vague ideal into something precise, and then criticize the details of it. Instead, I will point out a common thread in the thought of Einstein and some contemporary philosophers, who are more clear about their ideal of objective description. I will then direct my criticism at the views of these philosophers.

What was Einstein's beef with quantum mechanics? While he sometimes expresses negative sentiment about indeterminism or about non-locality, his summative judgment is that quantum mechanics fails to describe a reality that is independent of the perceiving subject.

> Fragt man, was unabhängig von der Quanten-Theorie fur die physikalische Ideenwelt characteristisch ist, so fällt zunächst folgendes auf: die Begriffe der Physik beziehen sich auf eine reale Aussenwelt, d.h. es sind Ideen von Dingen gesetzt, die eine von den wahrnehmenden Subjekten unabhängige (reale Existenz) beanspruchen (Korper, Felder, etc.), welche Ideen andererseits zu Sinneseindrucken in möglichst sichere Beziehung gebracht sind. (Einstein, 1948, p 321)
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> (English translation by Irene Born) If one asks what, irrespective of quantum mechanics, is characteristic of the world of ideas of physics, one if first of all struck by the following: the concepts of physics relate to a real outside world, that is, ideas are established relating to the things such as bodies, fields, etc., which claim a 'real existence' that is independent of the perceiving subject — ideas which, on the other hand, have been brought into as secure a relationship as possible with the sense-data. (Born, 2004, p 170)

Einstein repeats the criticism in his autobiographical account.

> Physics is an attempt conceptually to grasp reality as it is thought independently of its being observed. In this sense one speaks of 'physical reality'. In pre-quantum physics there was no doubt as to how this was to be understood. In Newton's theory reality was determined by a material point in space and time; in Maxwell's theory, by the field in space and time.

Here Einstein is explaining what he thinks is bad about quantum mechanics by pointing out what he considers to be good about other theories of physics:

they describe a reality whose existence is *independent* of any perceiving subject.[2]

Einstein's claim makes a lot of intuitive sense, but it contains a hidden ambiguity. In particular, if D is a description, and X is the state of affairs described, then is it D or X that is supposed to be independent of the describer? Einstein couldn't have intended to say that X must be independent describer, because that would not impose any requirement on the description D, nor on the describer herself. What's more, the describer doesn't have any say about whether reality is independent of her, so she could hardly be to blame if it is not. So, Einstein must have intended that an objective description will be independent of the describer. But what kind of thing could a description be such that it is independent of the describer?

Einstein believed that quantum mechanics fails to underwrite any categorical claims about reality, but only conditional claims of the form: "if a subject makes a measurement, then such and such outcomes are possible, with such and such probabilities". However, this picture misconstrues the role of the subject in producing quantum-mechanical descriptions. The subject doesn't play a causal role in bringing reality into existence, but a semantic role in determining the context of her description.[3] When Bohr spoke of the "epistemological lesson" of quantum mechanics, he sometimes reverted to vague formulations, such as "in the drama of existence we are ourselves both actors and spectators". However, his point is not that the drama of existence is created, in a causal sense, by the perceiving subject, but that the describer is entangled in the drama, and that imposes limits

[2]Einstein's view of objective description presupposes the physical separability of the describer and the described. On this point, Bohr agrees with Einstein — and then Bohr wrestles with the fact that, according to our best physics, describers may be entangled with the physical systems they are attempting to describe. For more details, see (Howard, 1979; Howard, 1989; Clifton and Halvorson, 2001).

[3]Throughout this article, I use "context" in the sense of Kaplan (1989). Where I differ from standard accounts of indexicals is in extending the notion of context to include things like frames of reference, or in the case of quantum mechanics, the classical experimental context (see Halvorson and Clifton, 2002; Landsman, 2017). I read Bohr as saying that the context of utterance might include the setup of an experiment, described in terms of "ordinary language supplemented with the terminology of classical physics". For example, in Bohr's example of the walking stick (Klein, 1967, p 93), there are two distinct descriptive contexts: one where the stick is part of the subject, and one where the stick is part of the object.

on her ability to describe it objectively.[4] In a certain sense Bohr's claim is completely obvious: if a person is entangled in something, then she might have to take special measures in order to say anything objective about it.

So, while Einstein aspired for a formalism that gives a picture of reality from the god's eye view, Bohr aspired for a formalism that gives correct descriptions of reality relative to contexts within that very reality. For example, in the Einstein-Podolsky-Rosen thought experiment, EPR ask (in my paraphrase): what is the real condition, i.e. from a god's eye view, of the second system? Bohr's reply is (in my paraphrase): ask not how god would describe the second system; ask how a finite subject would describe the second system. What's more, finite subjects have specific contexts which determine the concepts that can meaningfully be employed. For example, the context could include a fixed frame of reference, allowing the describer to employ the concept of position; or the context could assume that the system under study is closed, allowing the describer to employ the concept of momentum. For Bohr, it is not known apriori whether our familiar concepts will continue to be applicable in contexts beyond those for which they originally were adapted.

2 Bernard Williams and the absolute conception

I suspect that many contemporary philosophers have a view of objective description that is similar to Einstein's. But even so, few of them have articulated or defend the view. One exception is the moral philosopher Bernard Williams, for whom the notion of "the absolute conception of reality" plays a central role. Williams articulates this idea in his creative recounting of Descartes' philosophical project.

> What God has given us, according to Descartes, is an insight into the nature of the world as it seems to God, and the world as it seems to God must be the world as it really is. (Williams, 1978, p 196)

In other words, Reason allows humans to transcend their finite, limited perspectives, and to see things as God himself does. What's more, this god's eye view is given concretely by mathematical physics, i.e. the science of matter

[4] I owe this point to Howard (1979).

in motion. While humans experience objects in terms of secondary qualities, such as colors and temperatures, physics sees only geometrical configurations.

For both Descartes and John Locke after him, secondary qualities do not "inhere" in objects themselves, but arise from how those objects relate to peculiarly human modes of perception. For example, an apple is not red in itself, but is only red for a subject in a certain context, i.e. from a particular point of view. In contrast, primary qualities are absolute — they inhere in the objects themselves, and are independent of the point of view of the describer. Thus, the absolute conception is supposed to be "a conception of reality as it is independent of our thought, and to which all representations of reality can be related" (Williams, 1978, p 196).

In later philosophical work, Williams uses the idea of the absolute conception to develop a sophisticated moral relativism (see Williams, 1985). In particular, he claims to say that apparently conflicting systems of moral claims both amount to knowledge only if they are different perspectives on reality in itself.

> If what they both have is knowledge, then it seems to follow that there must be some coherent way of understanding why these representations differ, and how they are related to each other. (Williams, 1978, p 49)

Schematically: if one person knows that T_a while another person knows that T_b, then there must be a third conception T such that T_a is a correct account of T in context a, and T_b is a correct account of T in context b. In this way, T provides a consistency check for T_a and T_b: there is a way a world could be such that both T_a and T_b are correct.

One reason that Williams' picture is alluring — and difficult to refute — is because it is just that: a picture. We are supposed to imagine what it would be like to know the world as God would, and we are supposed to think of this blessed state as the telos of "pure inquiry". However, we aren't encouraged to ask questions such as: what exactly is a conception, and what concretely can we do to purify our conceptions of subjectivity and perspective? So, while Williams' idea of the absolute conception might serve as an inspiration, it cannot, without significant supplementation, serve as a concrete guide for scientific practice.[5]

[5]Putnam (1992, Ch 5) contains a sustained critique of the absolute conception. The debate is then continued in (Williams, 2000; Putnam, 2001). See (Moore, 1997) for an elaboration and defense of the absolute conception.

But now I'm going to be even more harsh: it's not just that the absolute conception is an unclear idea, it's incoherent. To see this, let's look at some of the kinds of examples that are supposed to motivate the notion of the absolute conception.

1. Suppose that Alice believes that the water in a certain bucket is warm, but Bob believes that the same water is cold. In that case, the absolute conception might be a description of the (objective) temperature of the water, or even better, a description of the position and velocity of the atoms that make up the water — as well as a description of Alice and Bob, the states of their brains, their histories etc., that predicts that they would feel the way the do.

2. Alice stands directly above a coin on the ground and she sees it as a disc. Bob is standing at some distance from the coin, and he sees it as an oval. The absolute conception describes Alice, Bob, and the coin as occupying regions in three-dimensional space. The projection of the coin on Alice's retina is a disc, and the projection of the coin on Bob's retina is an oval.

3. Alice is sitting on a boat traveling at a constant velocity while Bob is sitting on the shore. According to Alice's theory T_a, the boat is stationary. According to Bob's theory T_b, the boat is traveling at four knots east. The absolute conception T describes Alice, Bob, and the boat as spacetime worms.

4. Alice is holding a meter stick. Bob is flying past Alice in a spaceship, and he measures the stick as one-half meter. The absolute conception — provided by the special theory of relativity — describes the stick as a four-dimensional spacetime worm, with projections of differing lengths onto Alice and Bob's simultaneity hyperplanes.

These are standard examples that are taken to support the metaphor of absolute and relative conceptions, but they actually uncover an ambiguity in Williams' notion of a "conception".

On the one hand, a conception could be a sort of picture, without any specification of how to apply that picture to concrete reality. Let's call this a *conception in the non-descriptive sense*. For example, van Gogh's *Starry Night* is a conception in the non-descriptive sense, as is Tolkien's *Lord of* *the Rings*, a map of Middle Earth, the number 42, or Minkowski spacetime. On the other hand, a conception could be a specific attempt to describe physical reality. Let's call this a *conception in the descriptive sense.* For example, I have a conception in the descriptive sense of the Netherlands as a flat country where lots of people ride bicycles. Similarly, I have a conception in the descriptive sense of my coffee cup as topologically homeomorphic to a doughnut.

Williams equivocates between descriptive and non-descriptive notions of "conception", and this makes the notion of an absolute conception seem initially plausible. However, every conception in the descriptive sense is put forward by a person with a particular point of view, i.e. a person in a context, while the absolute conception is supposed to describe reality in perspective-free or context-insensitive way. In other words, the absolute conception is supposed to have the miraculous property of being a conception in the descriptive sense while lacking the features that every conception in the descriptive sense has.

To see the problem more clearly, imagine that you asked me what my conception of physical reality is, and I answered "42". Obviously, thinking of a number is not yet having a conception in the descriptive sense. What's more, it wouldn't much improve the situation if I said that my conception is that reality is represented by 42. The obvious next question would be "how is reality represented by 42?" because a mathematical object gives rise to a conception in the descriptive sense only when a person specifies how that mathematical object is intended to latch on to concrete reality. This moral holds not just for numbers, but also for the mathematical objects that play a starring role in contemporary physics. For example, "reality is represented by the manifold M" is not a conception in the descriptive sense, nor is "reality is represented by the wavefunction ψ". It takes more work to produce a conception in the descriptive sense than to consider a mathematical model and to think "reality is like this".

It is only by equivocating between descriptive and non-descriptive notions of "conception" that the classical examples seem to support the idea of an absolute conception. In the second example above, the absolute conception is supposed to be given by a mathematical object such as $(\mathbb{R}^3, a, b, C)$, where $a, b \in \mathbb{R}^3$ represent Alice's and Bob's locations, and $C \subseteq \mathbb{R}^3$ represents the coin. However, $(\mathbb{R}^3, a, b, C)$ is a mathematical object, and so it is only a conception in a non-descriptive sense. Similarly, in the third example, the absolute conception is supposed to be given by Galilean spacetime M and a couple of points $a, b \in M$ with velocity vectors v_a, v_b in their respective tangent spaces. But once again, the mathematical object (M, v_a, v_b) is a conception only in a non-descriptive sense. Nor could we get a conception in the descriptive sense by plugging the relevant mathematical objects into the sentence "there are things in physical reality to which X corresponds". This latter statement still lacks the determinate content that proper descriptive claims have.

I conclude that the above examples do not support the idea that there could be an absolute conception of reality, much less the idea that the aim of physics is to achieve the absolute conception. In none of these examples is there anything that could qualify both as a conception in the second sense (i.e. a descriptive claim) and as absolute (i.e. free from perspective). Based on such examples, I'm more inclined to think that descriptive claims are, by their very nature, contextual; and that the abstract objects — e.g. propositions, geometric shapes, manifolds, wavefunctions — that we employ to relate our relative descriptions to each other are not themselves "conceptions" in any epistemically relevant sense.

3 Metaphysics and the third theory

According to Bernard Williams, finding the absolute conception of reality is the objective of physics, and philosophers cannot be expected to contribute much to the achievement of this objective. But not all philosophers share Williams' modest view of their enterprise. For example, Hegel thought that he was in a better position than physicists — with their narrow focus on inert matter — to see reality as god sees it. Similarly, many analytic metaphysicians take themselves to be on the hunt for a description of the fundamental structure of reality.

Let's set aside the question of whose job it would be to find the absolute conception. What I want to understand is how adopting a certain ideal of objective description might influence the decisions that people make vis-a-vis research programs. It is my strong sense that Einstein's ideal of objective description played a central role in his rejection of quantum mechanics and his search for a grand unified theory. But I'll leave it to better historians than myself to evaluate whether my sense about that is correct.

I also have a sense that analytic metaphysics is often driven by an ideal of objective description that is similar to Einstein's. Indeed, Ted Sider (2020) states explicitly that if a description is true in a fundamental sense, then it must be free from every arbitrary contribution of the describer. This requirement leads to a sort of imperative:

> (Imperative of the third theory) If there are distinct theories T_a and T_b that correctly describe the same domain, then one ought to search for a third theory T that is free from the conventional features of T_a and T_b, and that explains why T_a and T_b are correct.

Sider himself applies this imperative to the following example.

Example (Mass scale)**.** There is a book on the table. One person, Kilo, says that the book weights one kilogram. Call her description T_a. Another person, Pound, says that the book weighs (approximately) 2.2 pounds. Call his description T_b. Which description of the situation should be adopted: T_a or T_b? How can we rationally decide between them?

Sider's answer to this question is that we cannot rationally decide between these two descriptions, and indeed, that both of them are defective for having conventional elements that are not part of their representational content.

> The fact that the number 1 is used isn't part of the representational content of the model; it's an artefact of the choice to use one scale rather than another for measuring mass. The objects aren't objectively 1 in mass, assuming there is no distinguished unit. (Sider, 2020, p 192)

So, T_a and T_b are apparently not objective descriptions, since a book is not objectively related weight-wise to either the number 1 or to the number 2.2. An objective description, says Sider, would need to be "unit free". He suggests, in particular, that a more objective description is provided by a theory of mass comparisons in terms of a binary relation $\succeq$. $\square$

Whenever a philosopher uses a specific example to make a general point, we should ask whether the example is paradigmatic of the phenomenon in question. Unfortunately, Sider's example of different mass scales is not paradigmatic of cases of "different perspectives on the same fundamental facts". Indeed, the mass scale theories T_a and T_b result from taking theory T, adding constant symbols corresponding to non-negative real numbers, and adding axioms for the semifield of non-negative real numbers. Thus, T_a and T_b are simply rigidifications of T in the sense that all elements of a model of T_a (or T_b) are labelled with constant symbols, and such a model has no non-trivial symmetries.[6]

In a more typical example of "different perspectives on the same fundamental facts", a theory T of the fundamental facts contains more information than any one of the perspectival theories; and, in fact, the perspectival theories can be deduced from T and information about context. Consider, for example, the case of a theory T describing a three-dimensional shape, where T_a is the theory of the projection of this shape onto the xy plane, and T_b is the theory of the projection of this shape onto the yz plane. In that case, T_a and T_b are derivable from T and information about context; and T is not in any sense the "common content" of both T_a and T_b.

Despite the fact that the example of mass scales does not generalize, I do think that Sider has put his finger on a general pattern of reasoning among metaphysicians — indeed, on a sort of common understanding of what it takes for a description to be objective. As Sider himself says:

> I think that many metaphysicians tend to assume (perhaps implicitly) something like the following: It's fine to construct models with artefacts. But there must always be some way of describing the phenomenon in question that (in some sense) lacks artefacts. There must be some way of saying what is really going on. For example, although we can model mass with real numbers, there must be some underlying artefact-free description, such as the $\succeq$ and C description, from which one can recover a specification of which numerical models are acceptable, and a specification of which features of the models are artefacts. (Sider, 2020, p 192)

If Sider is correct about this, then it explains a lot about the projects that metaphysicians choose to work on. One particular example that Sider could have discussed is the case of non-symmetric relations.

Example (Non-symmetric relations)**.** Peter Geach (1957): There is a tea cup a on top of a table b. This state of affairs can be described by the sentence Rab, where R is the relation "is above". The very same state of affairs can be described by the sentence R^*ba, where R^* is the relation "is below". Which theory should be adopted: the theory T_a stated in terms of the relation R, or the theory T_b stated in terms of the relation R^*?

[6]Another possible regimentation of T_a and T_b would have them as two-sorted theories with one sort for physical objects and another sort for positive real numbers.

Geach raised this issue over sixty years ago — and it continues to vex the best metaphysicians (see Williamson, 1985; Fine, 2000). Their responses range from rejecting the very notion that there can be asymmetric relations at the fundamental level (see Dorr, 2004) to attempts to construct a new formal logic that collapses the distinction between a relation R and its converse R^*. (For more on this issue, see MacBride, 2020.) For the present discussion, the interesting question is why metaphysicians believe that it is imperative to do anything. □

We see here a striking similarity between the visions of Einstein, Williams, and these convention-averse metaphysicians. For all of them, the aim is to find a description without any contribution from the describer. As Sider says, the aim is to find a representation that is free from "representational artifacts", i.e. any feature of the representation that is accidental to its role qua representation.

As with Williams, Sider has many uses for the absolute conception. This conception is not just the most perspicious representation of reality, it is also needed to establish the equivalence of perspectival theories.

> To support a claim of equivalence between a pair of theories . . . we brought in a third language, a language in which mass is described in a unit-free way, using the concepts $\succeq$ and C. This third, more fundamental, language gave us a perspective on the fundamental facts. (Sider, 2020, p 187, notation adjusted).

It's ironic that Sider says that the third theory T gave us a "perspective" on the fundamental facts, because of course he intends T to be non-perspectival. Thus, the third theory plays essentially the same role for Sider as the absolute conception plays for Williams — the only difference between them is that Sider, like Hegel before him, thinks that philosophy has something to contribute to the search for the absolute conception.

4 Spacetime is not the absolute conception

Accoring to a common way of thinking, spacetime theories — such as Einstein's special and general theories of relativity — reconcile the various frame-relative descriptions of states of affairs by embedding them in a god's eye view picture of the contents of spacetime. For example, Alice describes a boat (on whose deck she is sitting) as stationary, while Bob describes the same boat as traveling to the east at four knots. Alice's description is correct relative to her context, and Bob's description is correct relative to his context; but neither of them is correct in an absolute sense. For a description that is correct in an absolute sense, we should think of the boat as a four-dimensional extended object in spacetime.

This story is so commonplace that I'm tempted to call it the orthodoxy. One finds this point of view assumed by almost every philosopher who discusses special relativity — except for those who reject STR in favor of a Lorentzian theory (see Craig, 2001) and those who reject the idea that there is a single objective reality (see Fine, 2005). For example, Balashov (2010) argues that the three-dimensional appearances are projections of four-dimensional objects onto our respective hypersurfaces of simultaneity. The central idea is that a mathematical spacetime M with some contents Γ is supposed to yield a conception of reality *sub specie aeternitatis*; and our local conceptions, i.e. our respective worlds of appearances, can be obtained by deducing perspectival information from (M, Γ).

When discussing Bernard Williams, I argued that a mathematical model M is only a conception in a non-descriptive sense. To use M to form a conception in the descriptive sense requires that one relate the parts of M to parts of physical reality, and that presupposes a specific context, viz. a location (in a general sense) in physical reality. For example, if M is a rectangle, then I can use M to form a conception in the descriptive sense of a piece of paper on my desk. I can do this, for example, by imagining a context c that is located directly above my desk and looking down at it. From that context c, it is correct to say that the piece of paper is rectangular — and that can be cashed out roughly as saying that the projection of M onto the visual field of c is a rectangle.

Or consider the example where M is a map of Paris. Then I could correctly say that M describes Paris, if, for example, I imagine a context that is 5,000 feet directly above Paris and looking down. What's more, this context must include an orientation for the map, because if I change context by turning the map upside down, then it is no longer true that M describes Paris.

The situation is slightly more complicated for three dimensional objects. Suppose now that M is a mathematical cube. If I say that M describes the box that is sitting on the floor of my office, then what context am I implicitly assuming? Or is it the case that "M represents the box" is intended to be true independent of context?

Such a statement cannot be true independent of context. Just as a person might misalign a two-dimensional mathematical model with a two-dimensional slice of physical reality (e.g. if the map is turned upside down then "the map represents Paris" changes truth-value), so might a person misalign a three-dimensional mathematical model with a three-dimensional physical object. For example, if "M represents the box" is true in one context, but then the context is changed by rotating M, then "M describes the box" may no longer be true. It follows that "M represents the box" is implicitly contextual, even when M is a three-dimensional mathematical object.

There is no reason to think that the context-dependence of mathematical modelling suddenly ceases when we come to four-dimensional objects, or to the entirety of spacetime. Supposing that there is a mathematical object M that can be used correctly to represent spacetime, this same object M could be used incorrectly to represent spacetime. Whether M does or does not represent spacetime depends on the context, in a broad sense, of the person using it to describe. If "M represents spacetime" is true in one context a, then it is false in another context b. Therefore, M does not provide an absolute conception of reality.

Let's think about what it means to say that spacetime itself is always described from a particular point of view. All the points of view that we human beings know have the feature that they are located at a particular place and a particular time. What's more, the person with that point of view has a particular state of motion. In short, that person has a frame of reference in the sense that is familiar from physics. Thus, while a person may think of space and time as a whole, her description of space and time as a whole still presupposes a frame of reference.

What does it mean, then, to say that "spacetime is described by M" is true relative to a frame of reference? In the first instance, we might think that the analysis of such statements should follow the same model as the analysis of statements such as "the office is described by C", where C is a cube in $\mathbb{R}^3$. Roughly speaking, the statement "the office is described by C" is true in context p (a location in space, represented by $\mathbb{R}^3$) just in case the distances between that point p and the various bits of the office is the same as the distances between that point p and the various elements of C.

The case of representing spacetime is a bit more subtle since there is little consensus about how we should understand statements about future times.

However, the point I would insist on is that "M represents spacetime" is to be analyzed into statements about three-dimensional spatial and one-dimensional temporal distances from a context c. In other words, context-relative statements form the explanatory basis for the apparently context-insensitive statement that M represents spacetime.

To reinforce this point, imagine that Γ describes some distribution of matter in spacetime. I claim, then, that the relationship between (M, Γ) and frame-dependent descriptions is not asymmetric in the way that it would need to be for (M, Γ) to be the absolute conception. Recall that the absolute conception is supposed to be more fundamental than the various relative conceptions; and this asymmetry is what gives the absolute conception its unique epistemic authority. However, in the case of the special theory of relativity, all features of a mathematical model (M, Γ) are deducible from any one of the frame-relative descriptions. For example, if Γ is a timelike line in M describing a massive particle on an inertial trajectory, then Γ determines a unique position x_a, energy e_a, and velocity v_a relative to any frame of reference a. Conversely, any reference frame a and triple (x_a, e_a, v_a) determines a unique timelike line Γ. In short, a frame-relative description of the content of spacetime is logically complete in the sense that it entails every fact about the content of spacetime.

One might object that the frame-relative facts entail all facts only if all objects are assumed to follow inertial trajectories. However, the argument can be strengthened by taking into account all frame-relative facts, and not just the facts relative to a single frame of reference. Obviously, any curve Γ in M is uniquely determined by the projection of its tangent vectors onto all simultaneity hypersurfaces; and hence, all facts are deducible from the logical sum of all frame-relative facts. In short, there is no reason for thinking that the facts represented by the four-dimensional spacetime model are more fundamental than the three-dimensional, frame-relative facts.

5 Objective description and coordinates

Another popular myth is the idea that we can increase the objectivity of our descriptions by passing from coordinate descriptions to intrinsic geometric descriptions. The metaphor that often gets brought out here is directly analogous to the one that motivates Williams and Sider: there are context-bound individuals $a, b, \ldots$ with their coordinate descriptions $T_a, T_b, \ldots$. Then there is a coordinate-free, geometric description T from which all the coordinate descriptions can be derived. This coordinate-free description T is supposed to represent reality as it is in itself, while the coordinate descriptions $T_a, T_b, \dots$ involve arbitrary conventions, e.g. choosing to set the coordinate origin in one place rather than in another.

This picture exercises a strong grip, and yet I will argue that it is based on a confusion. Coordinate-free mathematical objects — such as affine spaces and manifolds — do not provide more perspicuous or more intrinsic descriptions of physical reality than coordinate descriptions do. A more accurate thing to say is that these abstract mathematical objects facilitate the harmonization of individual coordinate descriptions, or less metaphorically, these objects provide translation schemes between coordinate descriptions.[7]

Consider, for example, two distinct coordinate descriptions of space. For example, T_a might be a description of Princeton NJ where the origin of the coordinates is set at Nassau Hall while T_b is a description where the origin of the coordinates is set at 1879 Hall. According to the Einstein-Williams-Sider picture, these two coordinate descriptions both have the flaw of involving an arbitrary choice of origin. Williams and Sider would then say that there is an epistemic imperative to find a third, coordinate-free description T of Princeton. In this case, the obvious candidate for T is simply a two-dimensional affine space A, which has no preferred origin. Then saying "Princeton is represented by A" involves no arbitrary choice, and so it can be taken as the sought-after, more objective description.

There is, however, a problem with this suggestion. An affine space A is a set consisting of infinitely many distinct points. For a person to represent physical space by A presumably requires that person to coordinate points of A to points of physical space. But then this person is once again faced with a problem of arbitrary convention: should a particular point $a \in A$ be assigned to Nassau Hall, or should a be assigned to 1879 Hall? The theorist has to choose one or the other coordinatization, but neither of them is preferred by the physical situation. Thus, the problem of the arbitrariness of coordinate descriptions remains even if we replace numbers by other mathematical objects.

There is, of course, a precise sense in which an affine space A has less structure than a vector space V. In particular, for any vector space V, there is an affine space A such that V is isomorphic to $(A, 0)$. That is, a vector

[7] For a different argument for the same conclusion, see (Wallace, 2019).

space is precisely an affine space A plus a designated origin $0 \in A$. What's more, the symmetries of $(A, 0)$ are the subset of the symmetries of A that fix 0. It might seem then that representing Princeton with $(A, 0)$ involves the postulation of more structure than representing Princeton with A. But it all depends on the intentions of the describer. If a describer is well aware that she assigned 0 arbitrarily, and could have just as well assigned 0 to any other location, then her representation via $(A, 0)$ does not postulate any more structure than a representation via A. The important point is what the describer herself intends to be the degree of arbitrariness in her description. A person who represents Princeton by A might be taken to be saying that whatever point $a \in A$ she assigned to Nassau Hall was arbitrary — i.e. she herself is not committed to this choice being better than another. In constrast, a person who represents Princeton by $(A, 0)$ might be taken to be signalling that Nassau Hall has some theoretical significance, e.g. has some property that is going to play a role in explanations. The mathematical model does not itself determine how the describer intends to use the mathematical model to represent things.

6 Objectivity as covariance

I take it for granted that physics frequently succeeds in producing objective descriptions of physical states of affairs. However, *pace* Williams, physics has never gotten close to an absolute conception — and I'm not sure that the idea is even coherent. In that case, the burden is on me to explain what could be meant by an "objective description".

Recall that according to Einstein's ideal, an objective description is independent of the describer. We saw, however, that this ideal is caught on the horns of a dilemma: either it requires that the relevant state of affairs is independent of the describer (which places no requirement on the description), or it requires that the description is independent of the describer (which makes little immediate sense). Given that the first horn of the dilemma is a non-starter as an account of objective description, I propose that we work on the second horn of the dilemma, i.e. to make sense of "description D is independent of the describer s".

There are two paths we could follow at this point: on the one hand, we could attempt to decouple the description D from the describer — to consider it as an abstract object, such as a proposition, that exists independently of any human subject. In that case, there would be a trivially simple answer to the question "what is an objective description?", namely: an objective description is a set of true propositions. Or, if there is a a worry about the possibility of a description that is about describer herself (e.g. her preferences), then we could nuance the requirement as follows:

> (PROP) D is an objective description for subject s if D is a set of true propositions that make no reference to s.

But PROP has many problems. First, what does it mean for a proposition to make reference to a person? For example, does a proposition describing carbon atoms make reference to you or not? Second, PROP places a restriction on the description D, but not on the describer s, in conflict with the intuition that a subject is essentially involved in cases where the notion of "objection description" is relevant.

An even worse problem for PROP is that falls prey again to the problem with the first explication of Einstein's objectivity requirement, viz. it does not provide guidance about how to attain objective descriptions. It is generally supposed that when people say or write declarative sentences, then they assert propositions without further effort. So what is it that PROP requires of a describer? The only guidance that PROP gives to a person is that he should speak truly and not about himself. That hardly seems like helpful guidance for scientific practice.

The second path we could follow is the path of practical implementability. To this end, consider again the example of two people, Alice who finds the room temperature to be cold, and Bob who finds the room temperature to be warm. If Alice says

> (S_1) The room is cold.

then we do not normally think of her as asserting an objective fact. But why not? For one, Bob would not directly affirm S_1. Nonetheless, many philosophers of language would say that S_1, asserted by Alice, might pick out a true proposition, which is more transparently represented by the sentence:

> (S_2) The room feels cold relative to context a.

Does S_2 count as an objective fact? The answer to that question depends on what we understand by the context a. On the one hand, if "being in context a" simply means "being Alice", then S_2 might not be an objective fact. The problem in that case, I think, is that Bob might lack a rule for interpreting statements in context a into statements in his own context. On the other hand, the contexts a and b might be specified by parameters, and there might be well-defined transformation rules for a description D_a in context a to a description D_b in context b. In that case, I would consider S_2 to be objective, despite the fact that it makes explicit reference to a specific context.

To spell this idea out more fully, I propose the following sketch of an ideal for objective description:

> (Descriptive Covariance) For any two contexts a and b, and for any physical transformation $f : a \to b$, there is a translation $D_f : D_a \to D_b$ from the contextual description D_a to the contextual description D_b. Moreover, these various translations "commute" with each other in a rule-governed way.[8]

If Descriptive Covariance holds, then descriptions "co-vary" with the contexts — in the sort of way that might be expected for perspectival descriptions of a single, coherent reality. In this case, objectivity is captured not by the existence of a context-free description, but by the rule that connects the contextual descriptions.

Descriptive Covariance is just a sketch of an idea, and it raises many further questions. For example, what counts as a "rule" relating contextual descriptions of reality? Isn't the notion of "rule" so flexible that it is trivial to say that there is a rule relating different perspectival descriptions of reality? To this question I answer that we do have some intuitions about what might count as a reasonable translation between two descriptions, and furthermore, about the notion of uniformity. For example, in special relativity, the Lorentz transformations are a uniform rule in the sense that the contextual parameters play the same role in determining the translation from one frame of reference to another. Similarly, in the logical theory of models, there is a precise definition of when a concept is definable uniformly across all models of a theory.

The ideal of objectivity as "covariance relative to context" finds inspiration in Niels Bohr's account of the aims of physics. First of all, Bohr explicitly rejects the idea of a god's eye view description of reality (see Favrholdt, 1994;

[8]For those familiar with category theory: Descriptive Covariance is basically the requirement that there is a functor from contexts to descriptions.

Favrholdt, 2015).[9] Nonetheless, Bohr maintains that the goal of physics is to provide objective descriptions of states of affairs, where objectivity is equated with a lack of ambiguity, i.e. with *Eindeutigkeit* (German) or *entydighed* (Danish).

> Every scientist is constantly confronted with the problem of objective description of experience by which we mean unambiguous communication. (Bohr, 1958, p 67)

> We must strive continually to extend the scope of our description, but in such a way that our messages do not thereby lose their objective or unambiguous character. (Petersen, 1963, p 10)

> ... our task must be to account for such experience in a manner independent of individual subjective judgment and therefore objective in the sense that it can be unambiguously communicated in ordinary human language. (Bohr, 1963, p 10)

The idea here is that there should be a rule such that for any correct description D_a relative to context a, and for any other context b, there is a unique translation of D_a into D_b. In this sense, the descriptions are uniquely interpretable, i.e. *eindeutig*, which Bohr takes to be a necessary condition for objectivity.

7 Conclusion

"Being objective" is an important virtue for scientists, and producing objective descriptions is among the more important goals of science. Nonetheless, it seems to be quite challenging to give a precise characterization of this virtue of objectivity. Indeed, some of history's greatest scientists have had radically different views about the nature of objective description.

With due respect for Einstein's scientific genius, his view of objective description — as a description of reality as it is in itself — is ambiguous, and

[9] In this regard, Bohr follows his teacher Harald Høffding, who adapted the view of his own teacher Rasmus Nielsen. Høffding (1909, Ch 16) relays Nielsen's claim that an objective description presupposes an "objectifying subjectivity". Høffding then argues that Nielsen should have concluded from this fact that a god's eye view of reality is an incoherent notion.

on some disambiguations, it is simply nonsensical. What's more, Einstein's view works against the cause of objective description, insofar as it would encourage scientists to produce descriptions that are completely detached from any context. But there are no such descriptions; and if there were, then contextual beings like you and me would not be able to understand them.

It is understandable that Einstein, Williams, and Sider, among others, would take the notion of objective description to presuppose the existence of an absolute conception. In particular, the absolute conception is supposed to provide an objective standard for measuring the correctness of other conceptions. If there were no such standard, then what would we even mean by saying that a conception is correct?

I have a simple, if deflationary, answer to that question: correctness of a description is an irreducibly relational notion. That is, "D is a correct description of X" is a claim about a relation between a description D and concrete reality X which cannot be reduced to a conjunction of claims about D and X separately. In particular, to say that D is a correct description of X is not a matter of D being "isomorphic" to X (which would be defined in terms of D and X having certain monadic properties in common).

Now, if correctness of a conception is an irreducibly relational notion, then there is no longer any place for the absolute conception as a standard by which correctness of conceptions is measured. What's more, there is no reason to think that two relative conceptions are equivalent only if they are related in the right way to the absolute conception. In fact, I see no evidence to suggest that reality admits, ultimately, of just one correct description. All the evidence points in the opposite direction: every true description is essentially contextual.

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