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Fiction As a Vehicle for Truth: Moving Beyond the Ontic Conception[†]

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Abstract:
Despite widespread evidence that fictional models play an explanatory role in science, resistance remains to the idea that fictions can explain. A central source of this resistance is a particular view about what explanations are, namely, the ontic conception of explanation. According to the ontic conception, explanations just are the concrete entities in the world. I argue this conception is ultimately incoherent and that even a weaker version of the ontic conception fails. Fictional models can succeed in offering genuine explanations by correctly capturing relevant patterns of counterfactual dependence and licensing correct inferences. Using the example of Newtonian force explanations of the tides, I show how, even in science, fiction can be a vehicle for truth.

I. Fiction As a Vehicle for Truth

The idea that fiction can be an effective vehicle for truth has long been recognized in both literature and the arts. This expression can be traced back to an 1833 treatise by Jacob Abbott (1803-1879), who was a minister, children's book author, and professor of mathematics and natural philosophy at Amherst College. In this treatise, Abbott argues that fictional stories are not only an effective vehicle for communicating the truths of morality, but that they do so far more effectively than true accounts of moral acts. He writes,

> No ingenuity can transform the story of the Good Samaritan, or of the Interpreter's House, into historical records of matters of fact. All that we can say of them is, that the truth shines out so clearly, and predominates so decidedly, that we hardly consider them fiction; which is no more nor less than saying, that the work is skillful done; the object of making fiction the vehicle of truth, is successfully and safely accomplished. (Abbott 1833, p. 32)

Abbott is not alone in recognizing this role for fictions. In the context of art, Pablo Picasso, for example, writes "Art is a lie that makes us realize truth, at least the truth that is given us to understand" (Picasso 1923, p. 315). Similarly the Quaker author Jessamyn West writes, "Fiction reveals truths that reality obscures" (West 1957, p. 39). Common

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to these quotations is the idea that fictions can be an effective means by which we can come to understand truths that would otherwise be difficult to grasp.

While we may be willing to grant that fiction can be a vehicle for truth in the context of literature and art, most people are far less comfortable with the idea that fiction could be in the service of truth when it comes to science. Science, it is commonly thought, must deal only in the truth, the whole truth (if possible), and nothing but the truth. After all, isn't fiction ultimately antithetical to truth? Won't scientists be misled into a labyrinth of confusion and be lulled by the mere illusion of understanding if they trade in fictions?

Even those who have granted a limited function for fictions in science have denied that they can play a role in scientific explanation or in generating genuine knowledge. Hans Vahinger (1852-1933), for example, in his *Philosophy of 'As If'* identifies the following four key characteristics of scientific fictions: 1. Fictions deviate from reality; 2. Fictions are ultimately to be eliminated; 3. There must be an express awareness that the fiction is just a fiction; and 4. "Where there is no expediency the fiction is unscientific" (Vaihinger ([1911] 1952, p. 99).[1] Vaihinger emphatically denied, however, that explanation and understanding were among the goals of science for which fictions could be expedient. He writes, "Every fiction has, strictly speaking, only a practical object in science, for it does not create real knowledge" (Vaihinger [1911] 1952, p. 88); and further "The hypothesis results in real explanation, the fiction induces only an illusion of understanding" (Vaihinger [1911] 1952, p. *xv*). Elsewhere I have discussed Vaihinger's views in more depth, and defended the view that, *pace* Vaihinger, fictions do have a role to play in scientific explanation and in advancing genuine understanding (Bokulich 2009). Moreover, I have developed a model-based account of scientific explanation according to which fictions can explain (Bokulich 2008a,b, 2011, 2012). Lingering doubts have remained, however.

In what follows I want to diagnose (and ultimately excise) what I believe is a central source of the remaining resistance to the idea that fictions can advance scientific understanding and play a legitimate role in explanation: the ontic conception of explanation. Before critically engaging the ontic view, however, there are a few preliminaries that are important to articulate for a proper framing of my project. First, my account of explanatory fictions lies within a broadly realist approach to science. Second, I view both explanation and understanding as success terms: explanation requires gaining genuine insight into the way the world is, and understanding is not just an "Aha!" feeling. Third, I take it that scientists do actually succeed in giving genuine scientific explanations (not *would* give genuine explanations in some final, future physics) and that those genuine explanations occur across all the sciences (i.e., even the 'special' sciences). Finally, I endorse explanatory pluralism, according to which there can be more than one

[1] In Bokulich 2009 I argued that we should accept all of Vaihinger's conditions for scientific fictions except for condition #2, that fictions should be eliminated; science may choose to keep some fictions (e.g., the fiction of light rays) permanently "on the books" because of their great utility and fertility (p. 93).

scientific explanation for a given phenomenon (some of which might be deeper[2] than others, etc.).[3]

II. Who's Afraid of Fictions in Science?

The use of fictions is widespread across the sciences, as has been well-documented in several recent anthologies (e.g., Suárez 2009; Woods 2010). Moreover, in many cases, these fictions seem to play an explanatory role (e.g., Batterman 2009; Bokulich 2008a, 2008b, 2009, 2012; Weiskopf 2011). This use of fictional posits in scientific explanation runs counter to the received view of scientific explanation, according to which only true accounts and existing entities, processes, etc. can explain. Michael Strevens, for example, writes, "No causal account of explanation--certainly not the kairetic account—allows nonveridical models to explain" (Strevens 2008, p. 297). The difficulty, however, is that an examination of scientific practice reveals that models routinely play a central role in scientific explanation and that all models are nonveridical to some degree. Recognizing these incontrovertible points, those who deny that fictions can explain then try to sort model elements into the true and the false, and only the former are claimed to do any real explanatory work:

> The content of an idealized model, then, can be divided into two parts. The first part contains the difference-makers for the explanatory target. . . . The second part is all idealization; its overt claims are false but its role is to point to parts of the actual world that do not make a difference to the explanatory target (Strevens 2008, p. 318).

Whether such a clean decomposition and quarantining of the fictional and idealized elements is possible is ultimately an empirical question answerable to scientific practice. Elsewhere I have raised some doubts about whether such a quarantining is possible (e.g., Bokulich 2008b, 2009, 2012). My aim here, however, is to critically engage the underlying assumption about the nature of explanation that implicitly or explicitly drives these intuitions that fictions cannot explain. That assumption is the ontic conception of explanation.

The ontic conception of explanation was first articulated by José Alberto Coffa and further elaborated by Wesley Salmon. In *Four Decades*, Salmon recalls,

> Coffa is a staunch defender of the ontic conception of scientific explanation. . . . For Coffa, what explains an event is whatever produced it or brought it about. . . . Explanations, in his view, are fully objective and . . . exist whether or not anyone

[2] For a discussion of explanatory depth, see Hitchcock and Woodward (2003).

[3] The expression explanatory pluralism has been used to describe two different views in the philosophy of science: on the one hand it has been used to describe the fact that scientists use different kinds of explanations in different fields at different times (e.g., deductive-nomological, causal-mechanical, structural, etc.). On the other hand, more recently the expression has also been used to mean that multiple, scientifically acceptable explanations can be offered for a particular, given phenomenon (the sense being used here). Elsewhere I have referred to these as "Type I" and "Type II" explanatory pluralism, respectively (Bokulich (in progress)).

> ever discovers or describes them. Explanations are not epistemically relativized, nor . . . do they have psychological components, nor do they have pragmatic dimensions. (Salmon 1989, p. 133)

Salmon endorses the ontic conception of explanation, but wavers between two ways of thinking about it:

> Proponents of this [ontic] conception can speak in either of two ways about the relationship between explanations and the world. First one can say that explanations exist in the world. The explanation of some fact is whatever produced it or brought it about. . . . Second, the advocate of the ontic interpretation can say that an explanation is something . . . that reports such facts. It seems to me that either way of putting the ontic conception is acceptable. (Salmon 1989, p. 86)

In much of Salmon's writing and the subsequent philosophical literature, the former reading of the ontic conception has predominated. Salmon contrasts the ontic conception with what he calls the modal conception and the epistemic conception (though his articulation of these contrasts is, I believe, a bit confused and will not be further discussed here). It is important to distinguish a "conception of explanation", which is a view about *what explanations are*, from an "account of explanation", which is a view about *how explanations work*. For example, Salmon endorses both the *ontic conception* of explanation and the *causal account* of explanation. One can, however, reject the ontic conception of explanation (i.e., deny that explanations are things in the world, independent of human theorizing), but endorse the view that many explanations are indeed causal (i.e., involve citing and representing the relevant subset of causes of the phenomenon).

More recently, the ontic conception of explanation has been explicitly endorsed in several prominent accounts of scientific explanation. Carl Craver, for example, writes,

> Salmon’s most penetrating insight was to abandon the idea . . . that explanations are arguments. Instead, he defended an ontic view, according to which explanations are objective features of the world. . . . explanation refers to an objective portion of the causal structure of the world. . . . Objective explanations, the causes and mechanisms in the world, are the correct starting point. (Craver 2007, p. 27)

In this quotation we see Craver explicitly embracing the ontic view and arguing that explanations are the causes and mechanisms in the world themselves. Strevens similarly endorses the ontic conception writing,

> Philosophers sometimes talk as if an explanation were something out in the world, a set of facts to be discovered, and sometimes as if it were a communicative act . . . I follow the lead of most philosophers of explanation, and of most proponents of the causal approach in particular, in giving the first, ontological sense of explanation precedence.. . . from this point forward, I use explanation exclusively in the first, ontological sense. (Strevens 2008, pp. 6-7)

Both of these quotations articulate the core claim of the ontic conception, namely that explanations are the full-bodied objects in the world that push, pull, or cause things to happen: explanations just are (in the sense of 'are identical to') the particular rock, the particular collection of testosterone molecules, the Sagittarius A* black hole. Indeed it would seem *every* single thing in the universe (known or unknown) should be classified as an explanation on this view, since there is some phenomenon, no matter how trivial, for which it is causally (or otherwise) responsible. The claim is not just that these things are causes or causally relevant, but that they are further *scientific explanations*. Scientists and scientific theorizing are not actually needed for there to be scientific explanations; explanation is not a human activity on the ontic view.

Although they are logically independent of one another, historically, the ontic conception and the causal account of explanation have gone hand in hand. The rise of the causal account as the new orthodoxy in explanation, has hence brought with it a wide-spread endorsement of the ontic conception, though often in ways that are often not fully acknowledged or analyzed.[4] If one takes explanations to be the concrete entities in the world, then it certainly doesn't look like fictions could explain: a fiction does not actually exist, hence it does not belong to the class of worldly entities that could be counted as explanations. As we saw above, Strevens's commitment to the ontic conception leads him to deny that false models can explain. Similarly Craver writes, "If we say, in contrast, that false models explain, we are left scratching our heads about how a false model could be an explanation of anything at all" (Craver 2014, p. 50). If one assumes the ontic conception of explanation, then the prima facie explanatory power of fictions in science is indeed puzzling. But is the ontic conception correct? What was the original motivation for the ontic view? What are the alternatives to the ontic conception of explanation? Is the ontic conception really the most plausible of the views? Until very recently these questions have been drastically undertheorized.

III. The Retreat from the Ontic View

Recently the ontic view has come under fire from several directions. One of the earliest and most vocal critics of the ontic view is Cory Wright.[5] There are three components to Wright's (2012) criticism: first, he disentangles the mechanistic account of explanation from the ontic conception, arguing that one can adopt the former while rejecting the latter. Second he raises criticisms against the ontic reading of mechanistic explanation (largely via a linguistic analysis of how we use the word 'explanation'). And third, he defends (briefly) an epistemic reading of mechanistic explanation instead. Wright begins by noting that the ontic conception isn't the only way to think about

[4] James Woodward, for example, allies himself with the ontic conception, writing "The theory I am proposing is thus what Salmon (1984) calls a realist or 'ontic' theory of explanation (Woodward 2003, p. 202), though it is, on a strict reading, incompatible with his view (which I endorse here) that successful explanation does not require getting the fundamental ontology right (Woodward 2003,p. 223).

[5] Bechtel and Abrahamson (2005) cite Wright as being influential in leading them to adopt a non-ontic conception of mechanistic explanation.

mechanistic explanation. William Bechtel and Adele Abrahamsen, for example, view explanation as a cognitive activity, rather than as the objects/mechanisms in the world:

> [E]xplanation is a cognitive activity that involves representing and reasoning about nature. . . . linguistic representations are not privileged and often diagrams provide a better vehicle for representing mechanisms. (Bechtel and Abrahamsen 2005, p. 439)

Wright himself views explanation as a class of complex representations (Wright 2012, p. 376). This work makes clear that the ontic conception is not the only possible conception of scientific explanation, so we need to critically examine whether it is in fact the most plausible conception.

Wright's central critique is that the ontic conception of explanation does not respect our linguistic practices. He asks us to consider, for example, the following two sentences:

a.) The repeated exposure to loud noises *caus**ed*** Strummer's hearing loss.

b.) The repeated exposure to loud noises *explain**s*** Strummer's hearing loss.

Wright notes, "the two sentences. . . do not 'say the same thing'. . . . the first involves. . .a temporally bounded event prior to the time of utterance, the second involves an atemporal and unbounded event that has held up to the time of utterance and beyond (Wright 2012, p. 390). He concludes that it is a mistake to identify explanations with the causes themselves. More generally, Wright argues that when we say that a mechanism explains, we are really just anthropomorphizing and speaking metaphorically: vibrations cause, people explain.

What about Salmon's alternative reading of the ontic conception? In many places in Salmon's writings he articulates the ontic conception as an 'exhibiting' of the relevant entities and processes involved in the explanation:

> According to the ontic conception--as I see it, at least--an explanation of an event involves exhibiting that event as it is embedded in its causal network and/or displaying its internal causal structure. (Salmon 1984a, p. 298)

It is not entirely clear, however, what precisely Salmon means by 'exhibiting' or 'displaying.' Wright (2015) takes up the task of exploring the different possible ways one could construe the notion of exhibiting. He notes that while 'exhibiting' finds a natural interpretation on the epistemic conception of explanation (e.g., as either a representation or communicative act), it remains fundamentally obscure on the ontic conception. He argues that there is no way to unpack this term such that it is consistent with the fundamental thesis of the ontic conception: namely, that explanation denotes non-representational, mind-independent entities in the world.

In light of the inability to find a sense of 'exhibition' that is consistent with the fundamental tenets of the ontic conception, an alternative construal is that the notion of exhibition is not in fact a substantive part of Salmon's ontic conception after all, but is rather what Wright calls an empty "filler" term. It is this latter interpretation that seems to be adopted by the new ontic theorists. As Wright argues, however, the tendency to use words like 'exhibit' or 'display', but leave them unanalyzed is why the ontic conception has enjoyed what he believes is, an unwarranted success:

> For instance, Craver claims that *exhibition* should be deemphasized in Salmon's version of OC [the ontic conception]. . . . But the real problem is that filler terms like *exhibition* belie a deeply representational (epistemic, cognitive, etc.) approach to explanation, and so contravene the very conceptions of ontic explanation. . . . Indeed, neglect of the conceptual problems underlying Salmon's widespread use of *exhibition* is just what has misled some philosophers to injudiciously take up the ontic conception in the first place. (Wright 2015, p. 20)

As we will see, similar criticisms can be raised against Craver's invocation of normative constraints on explanation, which are similarly inconsistent with a thorough-going ontic conception.

In a recent paper Craver has reaffirmed his commitment to the ontic conception of explanation:

> Conceived ontically . . . the term explanation refers to an objective portion of the causal structure of the world, to the set of factors that produce, underlie, or are otherwise responsible for a phenomenon. Ontic explanations are not texts; they are full-bodied things. They are not true or false. They are not more or less abstract. They are not more or less complete. They consist in all and only the relevant features of the mechanisms in question. There is no question of ontic explanations being "right" or "wrong," or "good" or "bad." They just are. (Craver 2014, p. 40)

This is a nice clear statement of what the ontic conception of explanation is. Although Craver thinks this is the most important and fundamental notion of explanation, he admits that the term explanation is ambiguous, insofar as it is sometimes also used to refer to a communication, other times to refer to a text, and finally sometimes also used to refer to a cognitive activity. Craver wants, however, to place these other senses of explanation "down stream," and assert the primacy of the ontic conception.

Although Craver recognizes these other senses of explanation, he does not always do enough to distinguish which sense of explanation he is employing at various points in his discussion. For example, Craver frames this paper as a discussion about what a good theory of explanation should accomplish. He writes that there are two goals:

> The first is *explanatory demarcation*: the theory should distinguish explanation from other forms of scientific achievement. Explanation is one among many kinds of scientific success; others include control, description, measurement, and taxonomy. . . . The second goal is *explanatory normativity*. The theory should illuminate the criteria that distinguish good explanations from bad. (Craver 2014, p. 28).

While all this sounds plausible, if we substitute '$\text{explanation}_{\text{ontic}}$' in for the occurrences of 'explanation' in the above quotation it becomes incoherent. Explanation cannot be a form of scientific achievement or success if it denotes non-representational, mind-independent entities in the world. A rock or a flux of sodium and potassium ions is not a scientific achievement alongside prediction, measurement, and taxonomy, the latter of which are all human endeavors. Similarly, normative constraints are completely out of place on the ontic reading of explanation: one cannot distinguish good explanations$_{ontic}$ from bad; as Craver himself says in this same article (and as quoted above), they just are.

This seems to be a common problem for the ontic theorists: they find it difficult to talk consistently about explanation in the way we all naturally would, while remaining true to the ontic conception. The plausibility of the ontic conception then becomes artificially inflated by subtly equivocating between the ontic and epistemic conceptions of explanation. Phyllis Illari proposes to rescue the ontic theorists from this doublespeak by shifting the debate from a discussion of what explanations *are* to a discussion of *constraints* on explanations. She writes,

> [A]lthough they also sometimes appear to be arguing about what mechanistic explanations themselves are. . . . they are moving towards a focus on constraints. . . . I will frame the debate in these terms of normative constraints on explanation. . . . Within this new frame, I will argue that good mechanistic explanations must satisfy both ontic and epistemic constraints. (Illari 2013, p. 241)[6]

Although Illari diplomatically paints this as a win-win synthesis of Craver's ontic mechanistic explanation and Bechtel's epistemic mechanistic explanation, it is strictly speaking a rejection of the ontic conception as Craver defined it (e.g., Craver 2014, p. 40). The move to normative constraints (whether ontic or epistemic) requires admitting something like a representational view of explanation.[7]

In the move from a discussion of what explanations *are*, to what *constraints* explanations must satisfy (what Benjamin Sheredos (2016) describes as a semantic ascent and normative turn), Craver's next strategy is to argue for the primacy of ontic constraints over all others. He writes, "Representations convey explanatory information about a phenomenon *when and only when* they describe the ontic explanations for those phenomena" (Craver 2014, p. 28; emphasis added). Explanation$_{texts}$ then are to be judged as explanatory only to the extent that they faithfully describe the actual mechanisms in the world.[8] In the context of explanatory models (presumably a kind of representation or explanation$_{text}$) David Kaplan and Craver (2011) describe this as the "3M" (model-to-mechanism-mapping) requirement.

Although this marks a shift away from the original ontic view towards the representational view of explanation, it is one that still clearly denies that fictional representations can be explanatory. Craver does, however, admit the incontrovertible point that models contain idealizations and other falsehoods, and so allows that the 3M

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[6] Although Illari's (2013) paper was published before Craver's (2014), she is quoting and responding to an advanced copy or draft of Craver (2014), which had already been accepted for publication and is cited there as "Craver (2012)".

[7] Illari puts the point optimistically: "As Craver is now explicit in accepting the move to considering normative constraints on good explanation, I think he is bound to accept that some of the regulative ideals governing what makes a good mechanistic explanation include representational aspects" (Illari 2013, p. 251).

[8] Here I am using *explanation$_{text}$* to stand in for any broadly representational view, including models, diagrams, etc.

mapping requirement can be selective. Presumably, however, those idealizations and falsehoods cannot be in the "difference makers", as Strevens (2008, p. 318) would say, otherwise they would lose their explanatory status. Craver tries to sidestep the problem of idealization entirely by declaring it outside the scope of theories of explanation: "Terms like . . . 'idealized' . . . apply to representations. . . . [t]hey do not apply to the ontic structures. . . . Once these are separated, the problem of idealization is clearly not a problem for philosophical theories of explanation" (Craver 2014, p. 50). Bracketing for the moment questions about the merits of this claim, such a move is simply no longer available once one has made the semantic ascent and taken the normative turn. The problem of how the idealized $\text{explanations}_{\text{texts}}$ that scientists routinely offer can count as genuinely explanatory needs to be confronted.

Is this new, more circumscribed ground that the ontic conception has staked out, namely that ontic constraints have priority and that a faithful mapping of $\text{explanations}_{\text{text}}$ to $\text{explanations}_{\text{ontic}}$ is required in order to count as explanatory, ultimately defensible? Benjamin Sheredos (2016) has argued that it is not. He writes,

> If we take the normative turn, the true task for the ontic theorist who promotes EEM [$\text{Explanation}_{\text{text}}$–to–$\text{Explanation}_{\text{ontic}}$-Mapping] is to make good on its conjecture of the normative priority of ontic norms, showing that, whatever we mean by "$\text{explanation}_{[\text{text}]}$," its full success must constitutively involve "mappability" to $\text{explanations}_{\text{ontic}}$. (Sheredos 2016, p. [23])

He points out, however, that traditionally two central epistemic norms of $\text{explanation}_{\text{text}}$ are *generality* and *systematicity*. By 'generality' he means the invocation of categorical claims regarding *classes* of explananda and explanantia, and by 'systematicity' he means the specification of some principle of extrapolation that allows an explanation to be applied to multiple cases (Sheredos 2016, p.[4]). These norms are brought to the fore by unificationist accounts of explanation, for example, but govern scientific theorizing much more broadly. Sheredos concludes,

> [A] general and systematic $\text{explanation}_{[\text{text}]}$ has a distinct logical and explanatory import compared to that of a singular $\text{explanation}_{[\text{text}]}$ which 'maps' to a token concrete $\text{explanation}_{\text{ontic}}$. If EEM is still to be maintained as true, then there must be something distinctive in the ontic counterparts of general and systematic $\text{explanations}_{[\text{text}]}$. . . . The problem of universals arises when we ask what, if anything, could be the ontological counterpart of a representation (mental or otherwise) which has *generality* and not mere scope. (Sheredos 2016, p. [19])

Because systematic and general $\text{explanations}_{\text{text}}$ have different import than singular $\text{explanations}_{\text{text}}$, they cannot be credentialed by a token $\text{explanation}_{\text{ontic}}$ in the same way.[9] Rather than adopting a metaphysically otiose position about the reality of universals to save the ontic view, the more reasonable move is to concede that such ontic constraints, which require mapping $\text{explanations}_{[\text{text}]}$ veridically to concrete mechanisms the world, don't always have priority over epistemic norms.

[9] Sheredos raises this same objection against Strevens' "First Fundamental Theorem of Explanation" in his version of the ontic view (Sheredos 2016, p. [28]).

So far we have seen that the ontic view's desire to focus on normative constraints on explanations has required a move away from the view of explanations as concrete mechanisms in the world, towards something like a representational view of explanation (recall that while representations can be good/bad, objects in the world "just are"). The new claim of the ontic view is that the most fundamental normative constraint (that trumps all other normative constraints "downstream") is that $explanations_{text}$ must completely and accurately map to $explanation_{ontic}$--this is what distinguishes good $explanations_{text}$ from bad $explanations_{text}$. We then examined the argument that even this new version of the ontic view is not always tenable (e.g., when explanations involve a generality beyond singular cases). The way this debate has unfolded suggests that, in the context of discussions about normative constraints on explanation in scientific practice, the proper conception of scientific explanation is a representational one, and that epistemic constraints sometimes trump an accurate mapping to ontic entities, mechanisms, processes, etc. This does not mean that ontic constraints play no role in distinguishing adequate scientific explanations, but rather that we need to develop a more sophisticated account of what precisely the appropriate ontic constraints amount to in different contexts.

IV. Fictions, Understanding, and the Eikonic Conception of Explanation

Elsewhere I have defended a version of the representational conception of scientific explanation that I call the eikonic conception, which is named from the Greek word 'eikon' meaning representation or image (Bokulich in progress). According to the eikonic conception, not only are the *explanantia* representations of the relevant processes (entities, structures, etc.), but so too are the *explananda* representations of the phenomena to be explained. More specifically, they are representations of the phenomena contextualized within a particular research program and explanatory project. The same phenomenon in the world (whether it is functioning as an explanans or explanandum) can be represented scientifically in more than one way, and some representations lend themselves more easily to certain lines of scientific inquiry than others. In some cases this can simply involve representing the phenomenon at one of many different possible levels of abstraction or generality. In other cases, it can involve representing the phenomenon in ways that we know it is not.

When trying to understand the nature of scientific explanation, it is helpful to take a step back and remember why it is we seek explanations: the goal of explanation is, arguably, understanding. My aim here is not to defend a particular theory of understanding, nor to elaborate the intricacies of the relationship between explanation and understanding, but rather to argue that explanations involving fictional representations can genuinely advance our scientific understanding and lead to true insights.

When one looks at the history of science and contemporary scientific practice, one can find many examples of when scientists purposely represent the phenomenon they are trying to explain in ways that they very well know are wrong. A famous example is James Clerk Maxwell's vortex-idle-wheel model of the ether.[10] After introducing this

[10] For philosophical discussions of this case see Nersessian (2002), Morrison (2014), and Bokulich (2015).

fictional vortex model, Maxwell concludes, “we have now shown in what way electromagnetic phenomena may be imitated by an *imaginary* system of molecular vortices" (Maxwell [1861/62] 1890, p. 488; emphasis added). Maxwell is quite explicit that this is a fictional representation; nonetheless it is by reasoning with this fiction that he comes to the most important discovery of his career: that electromagnetic waves travel at the same speed as light, a coincidence that could only be justified by their identity. In other words, the fiction of vortices functioned as a vehicle for the truth that light is electromagnetic radiation.

More generally, the fictional mechanism is a representation or model of the true mechanism, and if it is a good one—one that captures the relevant structural features or patterns of counterfactual dependence—then it can (when used with due diligence) stand in for the true mechanism in the scientist's reasoning and explanations, even though the ontology of the fictional mechanism is wrong. Such cases are not limited to the history of science, and a contemporary example that I have discussed elsewhere in depth is semiclassical explanations of quantum phenomena, such as wavefunction scarring (see Bokulich 2008 or Bokulich 2009 for more details). These latter sorts of cases are particularly interesting because they are ones in which we have the fundamental theory and true ontology in hand, and yet still resort to the fiction for the purpose of gaining better physical insight.

There is often an implicit assumption that when scientists use fictional representations, they must be misguided or confused. As Catherine Elgin notes, however, "[t]hat misunderstanding involves representing things as they are not does not entail that whenever we represent things as they are not, we misunderstand them" (Elgin 2004, p. 120). Why would a scientist choose to make use of a fictional representation, especially if a veridical representation is at hand? There are, of course, all sorts of possible answers, but the relevant one here is that there are some cases in which the fictional representation better facilitates the sort of physical insight that is needed for a particular explanatory project. As Elgin further argues, fictions can "highlight certain aspects of the phenomena, reveal connections, patterns and discrepancies, and make possible insights that we could not otherwise obtain" (Elgin 2004, p. 127; see also Elgin 2007, p. 39). Obviously not just any fiction will do, and elsewhere I have suggested an approach for how one might go about distinguishing explanatory from non-explanatory fictions (Bokulich 2012).

Even if one has rejected the ontic conception of explanation in favor of a representational view, there is still a common presumption that a veridical representation is required for a successful explanation to be given and for genuine understanding to be gained. Strevens, for example, has recently argued that one has scientific understanding of a phenomenon just in case one grasps a correct scientific explanation of that phenomenon, and, moreover, an explanation can be correct only if its constituent propositions are true (Strevens 2013, p. 512). Although such a view might seem prima facie plausible, it is once again in tension with scientific practice. Maxwell clearly gained genuine scientific understanding of electromagnetic phenomena and the nature of light, even though he did not have a correct causal-mechanical explanation whose constituent propositions were true.

An alternative view of scientific understanding has been cogently defended by Elgin (2007) and Collin Rice (2016).[11] Both Elgin and Rice argue that models can provide genuine scientific understanding of a phenomenon without providing an accurate representation of the relevant features of that phenomenon. Elgin, for example, writes that the requirement that

> the propositions that express an understanding are true. . . . is unduly restrictive. It neither reflects our practices in ascribing understanding nor does justice to contemporary science. . . . I devise a more generous, flexible conception of understanding that accommodates science . . . and shows a sufficient but not slavish sensitivity to the facts. (Elgin 2007, p. 22)

Rice defends a moderate version of this view, according to which "most" of what one believes about a phenomenon must be true in order for there to be genuine understanding, but this understanding doesn't require accurate representation. Similar approaches have been developed by Mauricio Suárez (2004) in his “inferential approach to scientific representation,” Juha Saatsi (2011) in his "inferentially veridical representations," and more recently Jaakko Kuorikoski and Petri Ylikoski’s (2015) in their “inferentialist account of model-based understanding.” The key move here is the recognition that scientific understanding requires having true modal information and the ability to draw correct inferences, but that one can achieve this "factive understanding" without having a true or accurate representation. Certainly having an accurate representation is one way to get such modal information, but the success of idealized and fictional models in science teaches us that it is not the only way.

Obviously not all fictional representations will succeed in providing the scientist with such a factive understanding. A representational conception of explanation, in making room for a broader range of normative constraints on explanation, still needs to satisfy ontic constraints of some sort, otherwise it risks not informing us about the world at all. The key question, however, is precisely what form those ontic constraints should take. Here we consider three different candidates for what the ontic constraints on explanation should be: 1. only the entities and processes in the world themselves can explain; 2. only veridical representations of those entities and processes can explain; 3. only representations (veridical, idealized, or fictional) that provide factive understanding can explain. According to the original ontic conception of explanation, only the entities and processes in the world themselves can explain. This approach was shown to be highly problematic, if not incoherent. After the normative turn, the revised ontic approach, argued that only veridical representations can be explanatory. We might call this the "standard view" of the ontic constraint on explanation. As a blanket requirement, this construal of the ontic constraint was shown to be too restrictive, failing to recognize the ways in which fictional models (such as Maxwell's or the semiclassical theorist's) can succeed in giving us genuine physical insight and understanding in our explanations of certain phenomena.

There is a context in which I think something like the standard view is reasonable, and that is when one's explanation is specifically a project in ontology. If one's

[11] Although Elgin and Rice differ on their construal of 'factive understanding', I believe they are at bottom arguing for a similar point.

explanatory project is to discover what the "furniture" of some domain of the world is, then a veridical representation of that ontology (at least to some degree) seems a reasonable requirement for success.[12] Not all explanations are projects in ontology, however. In many cases, scientists know what the fundamental ontology of a domain is, but the relevant question concerns how those elements interact in complicated ways to produce the phenomenon of interest. In these latter sorts of cases, fictional representations can be especially perspicuous in highlighting the relevant features and patterns of dependence in the complex behavior that one is interested in. The relevant ontic constraint, then, is that the fictional representation facilitate correct inferences and factive understanding of the phenomenon.[13] This is precisely the sort of case we find in the semiclassical explanations of phenomena such as wavefunction scarring. The physicists were not engaged in trying to discover what the fundamental ontology or laws of quantum mechanics were; this was already taken for granted. The question instead was to try to gain physical insight into higher-level patterns of dependence in an enigmatic behavior. In the following section I will briefly illustrate these sort of cases (explanatory fictions that meet the ontic constraint of producing factive understanding) with the more familiar example of explaining the motions of the tides.

V. The Case of Gravity and the Tides

Consider the standard scientific explanation of the tides, as, for example, found on the National Oceanic and Atmospheric Administration (NOAA) website:

> [T]he moon and earth revolve together around their common centers of mass, or gravity [CoG]. The two astronomical bodies are held together by gravitational attraction, but are simultaneously kept apart by an equal [only at the CoG] and opposite centrifugal force produced by their individual revolutions around the center-of-mass of the earth-moon system. . . . At the earth's surface, an imbalance between these two forces results[,] . . . in the hemisphere of the earth turned toward the moon, [in] a net (or differential) tide-producing force which acts in the direction of the moon's gravitational attraction. . . . On the side of the earth directly opposite the moon, the net tide-producing force is in the direction of the greater centrifugal force, or away from the moon.
> (https://tidesandcurrents.noaa.gov/restles2.html)

This results in two tidal bulges of ocean water on opposite sides of the earth (the high tides). Thus, if you live somewhere like Boston Massachusetts, you will notice that there are two high tides and two low tides every day, as the earth rotates through these two bulges, roughly 12 hours apart (strictly speaking every half a *lunar* day, which is the time

[12] Even when it comes to projects in ontology, I suspect there can be some contexts in which there are multiple scientifically legitimate taxonomies that satisfy the accommodation demands of different domains of scientific inquiry, and so a more subtle story may need to be told about ontic constraints even the context of projects in ontology.
[13] This is intended as a minimal construal of the ontic constraint, not a full account of all the conditions that must be met by a good scientific explanation.

it takes the moon to again appear directly overhead, which is every 24 hours, 50 minutes, and 28 seconds).

The sun exerts a similar differential force (in the revolution around the common earth-sun system center of gravity); however, despite the sun's massiveness, its distance from the earth means that it exerts only half the force of the moon (the tide-generating force is inversely proportional to the cube of the distance). When the sun and moon are aligned for a new moon or full moon, the lunar tidal bulge and the solar tidal bulge reinforce each other (constructive interference), producing larger "spring tides", and when the lunar bulge is orthogonal to the solar tidal bulge (at first-quarter and third-quarter moons) then there is a destructive interference between the two tides and the tides are much lower ("neap tides").

Not every coast experiences two high tides and two low tides every day (semidiurnal tides) as one would expect. Some places, like the Gulf of Mexico and the coast of Southeast Asia, experience only one high tide and one low tide a day (diurnal tides), while other locations experience a complicated mix of these two tidal patterns, such as the west coast of the US. To explain why the tides arrive at a location when they do, one needs to add additional factors. One complicating factor is that the tidal bulges can't move at the speed of the rotation of the earth, but rather move at a speed proportional to the depth of the ocean, as a forced wave, and this results in the tidal bulge being broken up into a series of distinct cells centered on an amphidromic point. The presence of large bodies of land also affects the tides, by further interrupting the movement of the bulges and setting up a standing wave within the basin. The shape of the coast and off-shore depth of the water both have a large impact on the behavior of tides as well. As one textbook recounts, "A detailed analysis of all the variables that affect the tides at any particular coast reveals that nearly 400 factors are involved" (Trujillo and Thurman 2007, p. 288).

The received scientific explanation of the tides makes use of what we may call the gravitational force picture. According to our best current scientific theory of gravity, general relativity, however, there is no such thing as a gravitational force. Instead, general relativity teaches us that there is just curved spacetime. There is no force pulling on the earth's oceans, the oceans are just "trying to go straight in a crooked world."[14] In short, the gravitational force is a fiction. It is, moreover, not just a fiction used in the pedagogical context of textbooks, but a fiction used by scientists in their scholarly publications in top scientific journals such as *Physical Oceanography*. The gravitational force picture is, for example, used in Gouillon et al.'s (2010) explanation of the forced tidal response in the Gulf of Mexico, and in Skiba et al.'s (2013) study of the coupling between open-ocean and coastal diurnal tides as part of an explanation of why the "tides of the ice age, during which lower sea levels implied a much reduced area of continental shelves, were much larger than those of today" (Skiba et al. 2013, p. 1301), just to cite two arbitrary examples. Indeed a search of the *Journal of Physical Oceanography* reveals that there is not a single article on the tides that even once mentions general relativity, stress-energy tensors, or spacetime manifolds. I further suspect that there aren't any graduate programs in physical oceanography that require a course in general relativity. Are we to conclude from this that physical oceanographers' failure to provide a

[14] I owe this wonderful expression to my colleague, John Stachel.

veridical representation of gravity (in accordance with the revised ontic conception) means that they are not in fact offering genuine scientific explanations of the tides? Can only a spacetime physicist, who has a veridical representation of gravity to deploy, offer a genuine scientific explanation of the tides? Is there no explanation of the tides until we have a quantum theory of gravity?

The explanation of the tides is the province of physical oceanography, and, in that context, the appropriate scientific representation of gravity is the force picture. Physical oceanographers are not engaged in the ontological project of finding out what gravity is; rather, they are interested in how gravity interacts with other factors to produce the complex tidal phenomena that they are trying to explain and understand. In the context of this scientific project, the classical Newtonian force picture does a better job of making transparent the relevant patterns of counterfactual dependence, and moreover, more easily lends itself to the incorporation of the other relevant causal factors in the production of the tides, which are also represented in a Newtonian picture.[15]

The physical oceanographer's use of the fictional force representation of gravity is in no way inferior to an explanation of the tides that makes use of a veridical representation of gravity as the curved geodesic structure of a 4-D spacetime manifold whose metric is determined, in accordance with the Einstein field equations, by the stress-energy tensor of the matter fields. The heavy machinery of this veridical representation adds no scientific value to the physical oceanographer's explanation of the tides.[16] Indeed I submit that, if used, it would result in an inferior explanation for the reasons given above.

The physical oceanographers who use the gravitational force picture are not confused about the nature of gravity; they know very well that the gravitational force is a fiction, and even more importantly, they know that it is not (what I have elsewhere, following Niels Bohr, called) a "mere" fiction (Bokulich 2009). It is rather what I want to call a *credentialed fiction*: it is a fiction that the scientific community has examined in relation to a veridical representation and determined that, for certain contexts, it is an adequate representation that can succeed in giving genuine physical insight into, and factive understanding of, a phenomenon of interest; and if it is used properly, it will not lead scientists astray in their inferential reasoning.[17]

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[15] Juha Saatsi (forthcoming) has used the example of Newtonian gravitational force to argue that explanatory indispensability does not license a realist conclusion in the context of mathematics, and like here, argues that gravitational forces qualify as explanatory by correctly latching onto modal dependence relations.

[16] I am not saying that general relativity adds no scientific value in general--it is of course a tremendously important scientific discovery and is absolutely the appropriate representation in many scientific contexts; but explaining the ocean's tides is not one of those contexts.

[17] This credentialing process is related to what I have called the "justificatory step" in explanatory models (e.g., Bokulich 2011).

VI. Conclusion

By way of conclusion, let me briefly rehearse some possible objections to the view presented here and my responses. One objection was the worry that scientists will be misled into confusion and a false sense of understanding if they make use of fictions. As we saw with Vaihinger, part of what makes a fiction *scientific* is the express awareness that it is strictly speaking false.[18] Moreover I argued that the fictions scientists typically deploy are not "mere" fictions, but rather are *credentialed* fictions. This credentialing process can take place in a number of different ways. In the case of the tides, scientists have shown that the Newtonian gravitational force picture is an adequate approximation of the general relativistic account in the limit of slow-moving particles in a weak gravitational field (i.e., in the regime in which ocean tidal phenomena occur). In the case of Maxwell, the credentialing process seemed to involve a physical analogy between the fictional representation and the phenomenon of interest, in which both systems were describable by mathematical equations that take the same form (Bokulich 2015). In yet other cases, the credentialing process might involve showing that the fictional system and the real system of interest fall into the same universality class (e.g., Batterman and Rice 2014). In calling credentialing a process, I mean to signal that it takes place over an extended period of time, and, hence, some fictions may be farther along in the credentialing process than others. The credentialing process is by no means infallible, but it is no more or less fallible than the rest of scientific knowledge.

A second objection might be, why bother using a fictional representation if we have a veridical representation at hand? Isn't it always better to use the truest, most complete representation that we've got? I argued that sometimes a fictional representation does a better job of highlighting the relevant patterns of dependence than a veridical one. To very loosely paraphrase Jessamyn West, the fiction of Newtonian forces reveals truths that the reality of the 4-D pseudo-Riemannian spacetime metric obscures. Which representation of a phenomenon is best is, for example, a function of the relevant scale (e.g., spatial, temporal, or energy scale) of the phenomenon one is interested in, as well as the particular scientific context of the explanatory project.

A third objection might argue that any purported explanation that makes use of the Newtonian force picture can only, at best, tell us what the explanation of the tides *would* be, were Newtonian mechanics the true theory of the world. Strevens seems to defend such a view. In the same article in which he argues that an individual has scientific understanding of a phenomenon just in case one grasps a correct scientific explanation (and that an explanation is 'correct' only if its constitutive propositions are true), Strevens goes on to distinguish a secondary notion of understanding that he calls "understanding with." He writes,

> To have "understanding with" of Newtonian physics is to be able to construct or grasp an array of Newtonian explanations that are good in the sense that they are internally correct--they would be correct if only Newtonian physics were true. (Strevens 2013, p. 513)

[18] Vaihinger also required that a scientific fiction be expedient, in the sense of serving the aims of science.

I think this is an overly pessimistic view of the understanding that Newtonian physics provides. Newtonian physics continues to be a required part of our science curriculum because it provides us with an understanding of our *actual* world, not just some hypothetical one. The physical oceanographers who offer Newtonian explanations of the tides are gaining an understanding of the real oceans, not just the oceans of some imaginary world.

At the other extreme, one might argue that if they are doing real explanatory work and providing genuine understanding, then they must not be fictions after all. Jessica Wilson has defended such a view. She writes, "I defend Newtonian forces against the four best reasons for denying or doubting their existence" (Wilson 2007, p. 173). She explicitly denies that they should be thought of as fictions, and instead argues that they should be admitted as part of the (nonfundamental) ontology of the world. Robert Batterman has been accused of similarly reifying entities that our best current scientific theories say are fictions. In his discussion of Batterman's book, Michael Redhead writes,

> Now, says Batterman, the explanation of universality in catastrophe optics involves the notion of a caustic and this notion belongs to ray optics and has no smooth correspondence or reduction to any notion in wave optics. . . . What Batterman is effectively doing is to *reify* this auxiliary mathematics so that the ray structure become part of the physical ontology. (Redhead 2004, pp. 529-530)

The wave theory replaced the ray theory as our fundamental theory of light. The assumption here again is that, if the fictional representation of caustics (the envelope of light rays reflected by a curved surface) is doing work in a scientific explanation, we must be mistaken that it is a fiction and instead give it a realist interpretation. The view taken here is that the explanatory power of a posit does not automatically license a realist conclusion. I would argue that light rays are an explanatory fiction, one that has been credentialed by our best current science, and hence is a (fictional) representation of light that, when used appropriately, will give genuine insight into optical phenomena and not lead scientists astray.

A final objection might insist that it is the object in the world that is the real explanation, not any of our representations of it. This is just a bald reassertion of the original ontic conception. On the view defended here, objects in the world push, pull, dissolve, or otherwise cause things to happen, while it is people who explain. Redefining 'explain' to mean 'cause' (or its cousins) just unhelpfully muddies the waters. As we saw, however, it is difficult for either side to get traction in this semantic debate, and a more productive discussion involves the nature of the ontic constraints on explanation after the normative turn. On the revised ontic conception, now advocated by Craver (2014), the task of a philosophical theory scientific explanation is explanatory demarcation (showing how explanation relates to other scientific achievements) and explanatory normativity (what distinguishes good explanations from bad ones). A pre-requisite for such a project is the recognition that explanations are fundamentally some sort of representation, and the moniker 'ontic' now refers to a commitment to the primacy of veridical representations of what used to be called $\text{explanations}_{\text{ontic}}$.

Pace the revised ontic conception, I argued that for many explanatory projects in science, a veridical representation of the causes is not what is most important. Instead, the relevant consideration is whether the representation licenses correct inferences and provides scientists with true modal information. This is precisely what we see in the physical oceanographers' explanations of the tides. Physical oceanographers are not interested in a veridical representation of the ontology of gravity; this is already known and is not a representation that is useful for bringing out the relevant patterns of counterfactual dependence in the phenomenon they are trying to explain. When it comes to the ocean's tides, the credentialed fiction of Newtonian forces does a much better job. As Abbott would say, "the work is skillfully done; the object of making fiction the vehicle of truth, is successfully and safely accomplished."

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