A Modest Critique of Maudlin

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In "A Modest Proposal Concerning Laws, Counterfactuals, and Explanations," the first chapter of Tim Maudlin's book *The Metaphysics within Physics* (Maudlin 2010), Tim Maudlin makes the argument that laws of nature ought to be considered as ontologically primary. In the pages that follow, after defining some terms, I will attempt three things. First, and foremost, throughout this paper I will argue the following thesis: in key parts of the chapter, Maudlin does not make a clear distinction between the laws of nature and scientific theories. Second, I will provide a brief overview of the arguments of key authors that Maudlin addresses in his text. In giving these overviews, I will point out problems with points where Maudlin addresses their accounts, and how several of these problems stem from the lack of a distinction between scientific theories and laws of nature. Third, I will do my best to accurately and clearly articulate Maudlin's proposal for the ontological status of the laws of nature.

1. Definitions

Maudlin proposes that laws of nature are *ontologically primitive*, and he then clarifies that "ontologically primitive" means "...not logically derived from, and cannot be defined in terms of, other notions." (Maudlin 2010, pg 15)

Maudlin says the *laws of nature* are "the patterns that nature respects…" (Maudlin 2010, pg 12). Since he says that the *laws of nature* are ontologically primitive and therefore "cannot be defined in terms of other notions", his definition of this term is undoubtedly a mere description at best. It may be advisable to tease apart the description. "Nature" here seems to be referring to the physical or material world. The word "patterns" is relatively straightforward; perhaps we could also understand it to mean "regularity". The most difficult word in Maudlin's definition is the word "respects." Maudlin seems to mean the same thing as "follows" or "observes." It is difficult to find a different word that would not be used in an

analogical sense, thus anthropomorphizing nature. This perhaps points to the fact that he considers laws of nature ontologically primitive, and so any attempt to give a clear and complete definition of them is futile. We must simply accept them as primitive notions, as givens.

I agree with this description of the laws of nature, and for the sake of my argument, will take this as the definition. When I refer to the laws of nature, unless quoting other sources, I will be referring to them in this sense, namely, as "the patterns which nature respects" or, having the same meaning (as I understand it) "the patterns which nature follows".

Maudlin does not give a clear definition of *scientific theories* in his text, but he does say what *scientific theories* are commonly understood as: "…theories are often taken to be attempts to formulate the laws of nature…" (Maudlin, 2010, pg 37). I will be using the term *scientific theories* to mean something similar, namely, "the attempts of scientists to formulate models of the laws of nature."

2. Armstrong, van Fraassen, and Lewis

The key points where Maudlin does not seem to make a clear distinction between laws of nature and scientific theories are in addressing the views of David Lewis and David Armstrong. Maudlin introduces the chapter by discussing competing views about theories on the laws of nature, principally addressing those of these philosophers. In both cases, he seems to offer arguments that do not directly address what the authors are proposing in their theories of laws of nature. I will give an overview of the views of these philosophers and Maudlin's critique of them. I will give a brief overview of Bas van Fraassen's account not because of any fault in Maudlin's critique of it, but because it can give some insight into his critique of Armstrong's account. In Maudlin's critique of van Fraassen's account, he does make a clear distinction between laws of nature and scientific theories.

2.1. Armstrong

Maudlin first addresses the theory of laws of nature put forth by David Armstrong in Armstrong's 1983 book titled "What Is A Law of Nature?" (Armstrong 1983). I will give an overview of Armstrong's

account first. Maudlin's lack of a distinction between laws and theories is most problematic in this section of his chapter because he fails to see Armstrong as an ally and instead perceives him as an opponent.

Armstrong's theory of laws of nature takes relations between universal properties as primitives, but he ultimately seems to arrive at the nearly the same conclusion as Maudlin, because the relations between these universal properties are identified with laws of nature:

> "During the 1970s, three philosophers, Fred Dretske, Michael Tooley and myself, all put forward the idea that the laws of nature are relations holding between universals. The idea is not a new one. It may even be thought to have been anticipated by Plato (Phaedo, 102-107) . But in Dretske (1977) , Tooley (1977) , and Armstrong (1978, Ch. 24) , the idea seems to be more clearly articulated, and worked out in greater detail (especially in Tooley) , than it had been in previous discussion. The utterly natural idea that the laws of nature link properties with properties had never entirely been lost sight of. But it was now made the object of some systematic attention." (Armstrong 1983, pg. 85)

Relations between universal properties, Armstrong says as he develops the ideas in his book, are to be taken as the basis for the uniformities observable in nature.

Armstrong (1983, pp. 7-8) makes a clear distinction between laws of nature and scientific theories. In his book he discusses both in great depth. The first parts of Armstrong's book, on which Maudlin focuses his arguments, are about laws of nature. The second part of Armstrong's book also describes many aspects of scientific theories (called "law-statements" by Armstrong). In Part 1 of the book, "Assumptions", Armstrong explains that he assumes a Realist account of laws of nature, namely, that their existence in reality is independent of the existence of scientific theories (or "law-statements", as he calls them). He admits that the truth or falsehood of a scientific theory is dependent on the law of nature which it attempts to describe. Armstrong puts this assumption forward to distinguish between his own position and that of the regularity account of laws of nature, which would say that laws of nature do not exist, and that scientific theories simply describe regularities which appear to be governed by laws. This distinction so clearly made by Armstrong is a crucial one that Maudlin would be good to make early

on in his chapter. Maudlin seems to take the distinction for granted. While he does make the distinction in later chapters, his failure to make the distinction early on seems to get him into trouble in dealing with the arguments of Lewis and Armstrong.

Armstrong provides an alternative formulation for the laws of nature, but, given the tradition of formulating Humean uniformities as $(x)(Fx \supset Gx)$, he demonstrates that Humean uniformities can be derived from the laws of nature. He describes laws of nature as necessitation relations between universals, symbolized by $N(F, G)$, using the quantifier to indicate that N is a relation holding between the universals F and G. He argues that the necessitation relations between universals entail Humean uniformities $(x)(Fx \supset Gx)$:

> "We all three had exactly the same idea. Suppose it to be a law that Fs are Gs. F-ness and G-ness are taken to be universals . A certain relation, a relation of non-logical or contingent necessitation, holds between F-ness and G-ness . This state of affairs may be symbolized as '$N(F, G)$' . Although $N(F, G)$ does not obtain of logical necessity, if it does obtain then it entails the corresponding Humean or cosmic uniformity: $(x)(Fx \supset Gx)$. That each F is a G, however, does not entail that F-ness has N to G-ness:
>
> (1) $N(F, G) \rightarrow (x)(Fx \supset Gx)$.
>
> (2) $(x)(Fx \supset Gx) \nrightarrow N(F, G)$." (1983, pg. 83)

Armstrong goes on to explain that the entailment in (1) essentially says that "all Fs are Gs because being an F necessitates being a G". He explains that one strength of this entailment relation is that it immediately gives clarity to the differentiation between accidental uniformities and uniformities that are manifestations of a law of nature. Accidental uniformities and uniformities that are manifestations of a law of nature have the same Humean formulation, $(x)(Fx \supset Gx)$. *But* only genuine uniformities that are manifestations of a law of nature are entailed by a universal relation $N(F, G)$. This is because accidental uniformities do not arise from the properties of the thing, whereas manifestations of a law of nature do.

Armstrong then proposes several possible accounts for the entailment between the universals and the uniformities, all of which have their difficulties. First, it could take the form (P&Q) → P, where P is the uniformity, in which case the universal contains some surplus over and above the uniformity that is lost in the instantiation. Alternatively, it could be of the form P → (PvQ), which he says seems more promising with no further elucidation as to why. He goes on two give two further accounts:

> "If the entailment does not have one of these two simple formal structures, then it seems that we will have to say that the entailment holds in virtue of a *de re* necessity linking the relation between the universals, on the one hand, and the uniformity it 'produces,' on the other. This is the picture which I get from the *Phaedo*. The Forms up in Heaven are related in a certain way, and, as a result, a uniformity is produced on earth. Such a doctrine is extremely mysterious. The mystery is only a little reduced by bringing the Forms to earth and letting them exist only in their instantiations." (1983, pg. 86)

He gives a Platonic account first, speaking of the Forms in Heaven and explicitly citing the *Phaedo*. Then, suggesting that the Forms could alternatively be brought to earth and allowed only to exist in their instantiations, he gives a more Aristotelian account, though not explicitly saying so. This picture gives great clarity as to what he is referring to in speaking of universals - it seems that a Platonic understanding of his universals as Forms would be sufficient.

Ultimately, he settles on accepting N itself as a universal. Then the Humean uniformities that the law *N(F, G)* entail are particular instantiations of the law:

> This idea, that the state of affairs constituted by *N(F, G)* is itself a universal, will not solve the whole problem of understanding the entailment. In the end, as we shall see, the relation of nomic necessitation, **N, will have to be accepted as a primitive**. But if we can also accept that *N(F, G)* is a universal, instantiated in the positive instances of the law, then, I think, it will be much easier to accept the primitive nature of N. It will be possible to see clearly that if N holds between F and G, then this involves a uniformity at the level of first-order particulars." [Emphasis added] (1983, pg. 88)

Armstrong's acceptance of universal nomic necessitation relations as primitives is not far off from Maudlin's acceptance of laws of nature themselves as primitives as we shall see later. In fact, as quoted earlier, Armstrong, Dretske, and Tooley wrote in the 1970s about the idea that "laws of nature are relations holding between universals" (Armstrong 1983, pg. 85). And so, saying that universal nomic necessitation relations are primitives is equivalent, for Armstrong, to saying that the laws of nature are primitives. It is clear, furthermore, that Armstrong, in describing "laws of nature", is referring to the same thing as Maudlin, that is, to the "patterns that nature respects". Their accounts do not seem to be all that different.

To adequately portray Maudlin's critique of Armstrong, I will outline how Maudlin introduces him in the chapter. Maudlin begins by pointing out that most philosophical accounts of the laws of nature describe the laws of nature in the "logical empiricist formulation" $(x)(Fx \supset Gx)$, where 'F' and 'G' are purely qualitative, namely, they do not refer to specific individuals, places or times. He goes on to point out that this account of the laws of nature is lacking because (a) it does not distinguish between accidental concurrence and nomic necessitation, and (b) specific individuals could be uniquely identified by relating them spatially to one another if the world is spatially symmetric. Maudlin then goes on to point out that this account for the laws of nature can be strengthened by adding a modal operator so that the form becomes $\Box(x)(Fx \supset Gx)$. The modal operator is to be interpreted as "nomic necessity", but as Maudlin says,

> "...appending a box to a sentence and calling it nomic necessity is only marginally superior to appending 'It is a law that…', and can hardly be considered an informative analysis." (Maudlin, 2010, pg. 10)

Maudlin suggests that perhaps the difficulty with this formulation is the horseshoe, since material implication is weak. He goes on to consider Armstrong's theory of laws of nature, which replaces material implication with universal nomic necessitation.

Maudlin provides multiple critiques of Armstrong's theory. Maudlin first points out that the entailment of $(x)(Fx \supset Gx)$ from $N(F, G)$ is problematic.

> "According to the view developed by David Armstrong, a law holds if being an F necessitates being a G in virtue of a relation between the universals F-ness and G-ness. In Armstrong's formulation the law is symbolized as $N(F, G)$ (a's being F, a's being G), from which the offending horseshoe has been eliminated (Armstrong 1983, p. 90). This elimination, though, immediately poses a new problem, for $(x)(Fx \supset Gx)$ is supposed to follow from the law. In the view of some, e.g. van Fraassen, the gap between a fact about relations of universals and a fact about relations among their instances cannot be closed (van Fraassen 1989, pp. 97 ff)."

Bas van Fraassen, in "Laws and Symmetry", cited by Maudlin above, argues that any philosophical account of the laws of nature is hopeless because the laws of nature do not exist (van Fraassen 1989). Van Fraassen addresses philosophical approaches to laws of nature based on universals, citing Armstrong, Dretske, and Tooley as the main proponents, focusing attention on Dretske's formulation . He presents a fair-minded account of the universals account of laws of nature, explaining that they say there exist nomological (or nomic) necessitation relations between universals that entail instantiations of particular instances of those universals ($N(F, G) \rightarrow (x)(Fx \supset Gx)$ in Armstrong's formulation). He then presents arguments against the account, pointing out that the first problem arises from the "necessitation relation". He had previously made arguments in the book to the effect that necessitation accounts of laws of nature fail to distinguish between ordinary regularities and regularities that are actual manifestations of laws of nature. It is the nomological nature of the necessitation relation that makes these regularities manifestations of laws of nature, but we ourselves cannot make this distinction by observation alone. The strength of Armstrong's account, however, is that he does give a philosophical account for nomological uniformities observed in nature, and it seems that this was his primary goal. Developing criteria for whether scientific theories are accurate or not did seem to be of primary importance to him. This epistemological problem of not knowing whether the scientific theories that one has discovered truly reflect the laws of nature is one to which Maudlin gives a skeptical response. Second, van Fraassen argues that the instantiation of universals as particulars is problematic:

> "The law as here conceived is a singular statement about universals *A* and *B*. The conclusion to be drawn from it is about another sort of things, the particulars which are instances of *A* and *B*. True, the instances are, by being instances, intimately related to the universals. This is not enough, however, to make the inference look valid to us." (van Fraassen, 1989, p. 97)

Van Fraassen says making the inference is akin to making the inference from "*X* knows *Y*" that "All children of *X* are children of *Y*." And he continues that the argument must be modified to be made valid, perhaps to be "*X* has the same children as *Y*, therefore, etc." It is very unclear to me why he gives this example. Focusing on the quoted text by itself, what seems to be more clear is that van Fraassen does not have the correct understanding of what Armstrong means by universals and their corresponding particular instantiations. Being a nominalist, who denies the existence of universals (van Fraassen 1994), this is not altogether unsurprising. Armstrong is not speaking of universal *substances*, but of universal *properties*. Perhaps we could liken these universal properties most closely to what Aristotle refers to as the "qualities" of a thing. In *Categories*, Aristotle remarks,

> "The most distinctive mark of substance appears to be that, while remaining numerically one and the same, it is capable of admitting contrary qualities. From among things other than substance, we should find ourselves unable to bring forward any which possessed this mark."(Aristotle, *Categories,* pub. 2017)

Thus an individual man is capable, through change of being cold or warm, good or bad, etc. And from this it is clear how different men, being different instantiations of the same universal substance of man (not according to Aristotle's understanding, but Armstrong's) can also be very different from one another, admitting "contrary qualities". But qualities, on the other hand, such as color or shape, while admitting variation in degree, do not admit of contraries. Whereas particular substances can differ dramatically in likeness to one another and to the universal Form, or genus, of a dog, the particular instances of mass differ only by degree in their likeness to the universal property of mass. One example of a universal property applicable to the discussion of physics is mass. One object can have more mass, whereas another can have mass less. Van Fraassen seems to be thinking of instances of substances, not instances of

properties. This would explain why he remarks that the instances of *A* and *B* are "intimately related", but not sufficiently related to the universals *A* and *B* to bear the relation forward in their instantiation. It seems that perhaps this is why he gives the example of children and their parents, the children being, by analogy, instantiations of their parents. This short segway into van Fraassen will be followed up later, but it seems necessary to adequately address the arguments which Maudlin refers to.

Maudlin also criticizes the fact that $(x)(Fx \supset Gx)$, although not regarded by Armstrong as a law of nature, naturally influences his account.

Armstrong's account, although eschewing $(x)(Fx \supset Gx)$ as any sort of law, is still naturally regarded as influenced by that skeleton. The formula directs our attention to a relation between the predicates 'F' and 'G', and the universality of laws, enshrined in the quantifier, implies the universality of the relation. It is not a far step to suppose that this universal relation among instances derives from a relation among the universals denoted by the predicates…Given that the preliminary supposition about the logical form of laws can so strongly influence subsequent avenues of research, we ought to pause to ask whether $(x)(Fx \supset Gx)$ is really a useful place to begin. Does it contain features that laws lack? Does it ignore structure commonly found in laws?"

Maudlin is arguing against the formulation of a particular Humean uniformity $(x)(Fx \supset Gx)$ that Armstrong says is entailed by the laws of nature themselves. Armstrong claims that these Humean uniformity are instantiations of the laws of nature, not the laws of nature themselves. It is not the place where Armstrong begins. The nomic necessitation relations between F-ness and G-ness, $N(F, G)$ are what Armstrong claims are the laws of nature, when he finally gives a "reasonably perspicuous" account for the entailment between these formulations:

> "In this way, I hope, we finally obtain a reasonably perspicuous view of the entailment:
>
> $N(F, G) \rightarrow (x)(Fx \supset Gx)$
>
> Transfer in thought the concept of necessitation from the sphere of particular states of affairs, taken simply as particular, to the sphere of sorts or types of states of affairs, that is, universals. Instead of a's being F necessitating it to be the case that a is G, without benefit of law, we have

> instead something's being F necessitating that something to be G, where a type of state of affairs (the universal F) necessitates a type of state of affairs (the universal G). It is then clear that if such a relation holds between the universals, then it is automatic that each particular F determines that it is a G. That is just the instantiation of the universal *N(F, G)* in particular cases. **The left-hand side of our formula represents the law, a state of affairs which is simultaneously a relation. The right-hand side of the formula represents the uniformity automatically resulting from the instantiation of this universal in its particulars.**" [Emphasis added] (Armstrong 1983, pg. 87)

So Maudlin's emphasis on criticizing the formulation $(x)(Fx \supset Gx)$ in Armstrong's account is misplaced. This formulation of Humean uniformity is not Armstrong's own, nor is it critical to his account. It is entailed by his formulation of the laws of nature, but the laws of nature themselves are represented as *N(F, G)*, as Maudlin himself points out. And the formulation of the laws of nature are what is truly essential to Armstrong's account.

Maudlin makes a further objection to Armstrong's account, pointing out that it is *ignotum per ignotius* ("the unknown through the more unknown"), that is, Armstrong is trying to explain something obscure by means of something that is more obscure:

> "...do we really have a firmer grasp of what a necessitation relation between universals is than we do of what a law is? This is especially troubling since the species of necessitation at issue must again be denominated nomic necessitation." (Maudlin 2010, pg 11)

Maudlin considers that laws are preferable as primitives because they are more familiar or easily understood than necessitation relations. This argument of Maudlin's is well-targeted because he is attacking the core of Armstrong's account, namely, the formulation of laws of nature as necessitation relations between universals, namely *N(F,G).* Essentially, Maudlin is saying that laws of nature are more familiar to us than universals, and therefore serve as better primitives than universal necessitation relations between universals. Armstrong, however, offers a comprehensive and perspicuous overview of what he means by universal necessitation relations between universals in his book. Universals are a

concept that has been studied in philosophy for millenia, and necessitation relations are a principle of basic logic. The answer to Maudlin's question, as to which we have a firmer grasp on, does not seem obvious to me. And if universal necessitation relations are the primitives that we ought to accept, then they ought to be accepted as primitive whether they are immediately obscure or obvious. Finally, in his "Assumptions" section of the book (1983, pg. 8), Armstrong makes a point of mentioning that he assumes the existence of universals, and points readers to his previous work from 1978, "Universals and Scientific Realism", for his arguments for their existence and details of his views about them.

Perhaps one thing that does obscure Armstrong's account: it is his lack of good examples. Armstrong would do well to describe clearly the relations between scientific theories (approximations to the laws of nature) and scientifically discovered properties (approximations to universal properties). Maudlin points this out as a critique of Armstrong's method, but does not seem to think there is hope for Armstrong's theory. Maudlin makes this playful jab at Armstrong that

> "An appropriate place to begin is with some real scientific theories rather than with cooked examples of the 'All ravens are black' variety."

Though Maudlin does make a legitimate critique of the examples Armstrong proposes in his book, I think that Armstrong's theory of universals can be quite easily applied to examples of scientific theories. As a simple example, Newton's Universal Law of Gravitation can be given as "All objects with mass are always attracted by an inverse square law." It seems to me that this is a perfectly acceptable (and widely accepted) expression of Newton's Universal Law of Gravitation written as a universal nomic necessitation relation ("attracted by an inverse square law") between universal properties ("mass" or "objects with mass"). On the other hand, perhaps Armstrong was perfectly justified in avoiding the use of real scientific theories as examples because real scientific theories are simply not the same as laws of nature, as he lays out so clearly in his "Assumptions" at the start of the book. Can we say with certainty that we know any of the laws of nature? Given the history of science, we know that even the most reliable and relied upon theories are bound to be replaced by better ones at some point. The use of abstract examples of the "All ravens are black variety" may perhaps be a better way to go.

Armstrong says that laws of nature are universal nomic necessitation relations between universals, and that these necessitation relations are primitives. Maudlin simply says that laws of nature are primitives. Armstrong and Maudlin are saying the same with regard to what is ontologically primitive. Armstrong focuses attention on what the laws of nature as primitives are, providing an in-depth analysis of what it means for them to be universal necessitation relations between universal properties. Maudlin, on the other hand, provides a deeper analysis of the relationship between the laws of nature and their instantiations as "FLOTES". Yet they are both saying that the laws of nature are primitives.

2.2. Bas van Fraassen

Maudlin makes a clear distinction between scientific theories and laws of nature in his critique of Bas van Fraasen. Maudlin introduces Bas van Fraassen's account by pointing out that van Fraassen abandons laws of nature altogether. Instead, van Fraassen focuses attention on scientific theories and on scientific practice in general. But, Maudlin points out, "theories are often taken to be attempts to formulate the laws of nature" (Maudlin, 2010, pg 37). So, van Fraassen must account for what scientific theories are in a different way. Maudlin explains Bas van Fraassen's account as follows:

> "His solution lies in a particular interpretation of the semantic conception of scientific theories. Although theories are often presented as (more or less) axiomatized systems from whose axioms the models can be determined, van Fraassen sees the axioms or formulation of laws as merely accidental artefacts. The content of the theory is not in the laws but in the set of models one ends up with: 'if the theory as such is to be identified with anything at all—if theories are to be reified—then a theory should be identified with its class of models' (van Fraassen 1989, p. 222). Van Fraassen adds to this view his own peculiar account of the objectives of theorizing. Famously, he believes that science is not a search for theories which are true, i.e. which contain a model which correctly describes the entire actual world, but rather theories that are empirically adequate, i.e. which contain a model which fits all of the observable phenomena in the actual world." (Maudlin 2010, pg 37-38)

In this long quote Maudlin describes two major problems that he finds in van Fraasen's account of theories. First, Maudlin finds it a problem that van Fraasen reifies the class of models that a theory ends up with instead of the laws of nature - this runs counter to Maudlin's claim that laws of nature are ontologically primitive. This first disagreement will be considered later in section IV. Second, Maudlin disagrees with van Fraasen's account for the objectives of theorizing. Van Fraasen believes that scientists attempt to search for theories that are "empirically adequate", not theories that are true. Van Fraassen's belief that science is not in search for theories that are true, but rather for those which are "empirically adequate" is clarified in his 1980 book, "The Scientific Image" (Oxford: Clarendon Press):

> "A scientific theory is ***empirically adequate*** if it has a model such that all appearances [i.e. structures which can be described in experimental and measurement reports] are isomorphic to empirical substructures of that model." (van Fraassen 1980, p 64) [Emphasis added]

Maudlin considers what van Fraassen can mean by "empirically adequate." Science does not merely aim at *empirically adequate* theories: if that were the case, a theory which empirically describes every logical possibility in the known universe would fit the bill. This would admit of "anything goes" theories which empirically describe all that we empirically observe. Such theories have neither the explanatory power nor the predictatory power sought after by scientists. "Such a 'theory' would not explain anything, and could not be used to predict anything, but it would be empirically adequate." (Maudlin, 2010, pg. 38)

Nor do scientists seek *ontological adequate* theories. Such theories would be empirically adequate, but also all the objects in the theory would stand in a one-to-one relationship (isomorphic) with all the objects in the real world. The "anything goes" theories which plagued the merely empirically adequate theories are still present among these ontologically adequate theories, and we have no way to distinguish between the stronger and the weaker theories. Maudlin's explanation as to why this is the case is not thorough except that he says it is the same reason as the empirically adequate theories, namely, that such ontologically adequate theories would only provide descriptions, not explanations or predictions. So, there is no criteria to discern between stronger and weaker theories.

Finally, Maudlin considers the criteria of *metaphysical adequacy* for theories. Such theories require that we accept the metaphysical reality of the physical world. For an empiricist like van Fraasen, this is not possible. Maudlin describes metaphysically adequate theories as

> "theories whose models stand in one-to-one correspondence with the physically possible states of affairs, each model being isomorphic to a state. On the view that we seek theories that correctly state the laws of nature, this is true. But it is unavailable to van Fraassen unless he reifies the physically possible worlds, and is unavailable on general empiricist grounds even then. So we are still left with the questions: how do we slim down our theories and how does their explanatory power increase in virtue of reducing the class of models?" (Maudlin 2010, pg. 38)

Maudlin's critique of van Fraasen's account of "empirically adequate" theories is summarized in a quote already referenced earlier on:

> "Such a 'theory' would not explain anything, and could not be used to predict anything, but it would be empirically adequate." (Maudlin, 2010, pg. 38)

Bas van Fraassen is an empiricist and a nominalist, and he denies the existence of universals, laws of nature, and necessity. He explicitly denounces a realist metaphysical view of philosophy of science in "The World of Empiricism", published in 1994:

> "There are no necessary connections in nature, no laws of nature, no real natural bounds on possibility. Those ideas all resulted when philosophers projected familiar models onto the natural world. Really, nothing is necessary, and everything is possible." (Van Fraassen, 1994)

In a recent podcast (Maudlin & Erhardt, 2023), Maudlin makes it very clear that his current view is that of scientific realism, though he does not admit to being a realist at the time of this paper (2010). He does attribute real existence ("ontological status") to things like laws of nature, and so, like David Armstrong, he is a realist at least in some sense. That is, he believes that the laws of nature, i.e. "the patterns that nature respects," (Maudlin, 2010) do truly exist, in separation "from the minds which attempt to grasp them" (Armstrong 1983).

This short account of Maudlin's critique of van Fraassen helps us to see two things: First, Maudlin clearly distinguishes between scientific theories and laws when he addresses Bas van Fraasen's account because he is forced to do so, since van Fraasen abandons laws for the sake of theories. Second, we see that van Fraassen, as a nominalist and empiricist, would never be able to allow for a connection between universals and their relations between particulars. This therefore makes Maudlin's mention of van Fraassen's as an objector to Armstrong's account quite surprising, as van Fraassen and Armstrong disagree at such a fundamental level. One is a realist, whereas the other is an empiricist. And as a consequence, van Fraassen cannot admit universals into his worldview, and he even abandons the notion of laws of nature altogether.

2.3. Lewis

Maudlin cites arguments proposed by David Lewis in chapter 3 of Lewis' book *Counterfactuals* (Lewis 1973, pp. 72-77). Lewis states the theory of laws of nature that he adopts as follows:

> "[A] contingent generalization is a *law of nature* if and only if it appears as a theorem (or axiom) in each of the true deductive systems that achieve the best combination of simplicity and strength." (Lewis 1973, pg. 80)

The laws that Lewis refers to are "consequences of propositions" and "axioms…in a deductive system". Therefore, Lewis seems to be referring to "laws" that are invented or discovered by human reasoning, i.e scientific theories. He does not seem to be referring to the patterns that nature respects.

Furthermore, he describes these deductive systems as balancing simplicity and strength. These deductive systems are not meant to be simply an omniscient description of the patterns nature respects. They balance simplicity, by which he means axiomatic simplicity ("some systems can be axiomatized more simply") and strength or "informational content". The balance of simplicity and strength makes scientific theories more practically useful and makes the universe more intelligible to humans.

Lewis mentions later several benefits of this theory which indirectly help to clarify what he means by the phrase "laws of nature." He gives the example of Bode's Law and explains that we can

know by exhausting instances that it appears to be true, but not yet know if it is a law of nature. Bode's Law is an empirical law, which he is arguing could eventually be brought in as an axiom for some scientific theory, but we do not yet have that theory yet. This example that he gives seems to support the notion that Lewis is speaking of scientific theories when he speaks of "laws," or at least axioms of scientific theories. Lewis also mentions this additional benefit:

> "It explains why we have reason to take the theorems of well-established scientific theories provisionally as laws. Our scientific theorizing is an attempt to approximate, as best we can, the true deductive systems with the best combination of simplicity and strength." (Lewis, pg 73)

We could parse out this argument as follows:

I. "A contingent generalization is a law of nature if and only if it appears as a theorem (or axiom) in each of the true deductive systems that achieve the best combination of simplicity and strength." (Lewis 1973, pg 73) This is Lewis' restatement of Ramsey's theory of lawhood.

II. Our scientific theories are attempts "to approximate, as best we can, the true deductive systems with the best combination of simplicity and strength." (Lewis 1973, pg 73)

III. The theorems of our scientific theories are therefore our best approximations to laws of nature and should be taken provisionally as laws of nature.

This argument hinges on the notion that scientific theories are attempts to approximate true deductive systems with the best combination of simplicity and strength. It does seem to be the case that scientific theories gradually approach the axioms of the best true deductive systems. But these are not the laws of nature, but some sort of idealized scientific theories.

Maudlin takes issue with several of Lewis' points, among them the consideration of possible worlds. This was not mentioned previously but will be considered below. A more central issue, for the purposes of this essay, is the issue of the determination of a law. Maudlin makes the argument that Lewis takes a regularity view of the laws of nature. Lewis does propose a theory of laws of nature that is fundamentally based on regularity. What he means by "laws of nature" is very different from what

Maudlin takes him to mean. As was argued earlier, when Lewis writes, "laws of nature", he is actually referring to scientific theories. Maudlin says the following about Lewis' regularity view:

> "On Lewis's sophisticated regularity view the two questions have a single solution. What makes a regularity into a law is that it appears in all of the simplest, most informative true theories of the world (Lewis 1973a, pp.72–7, see also 1986a, pp. 122–31). We can get at least presumptive evidence about what the laws are by formulating as many such theories as possible; an ideal epistemic agent provided with all of the particular facts about a world could, in principle, determine the laws from this information."(Maudlin 2010, pg. 15)

The "two questions" Maudlin writes about are an ontological and an epistemological question. The ontological question is "what really exists?" The epistemological question is "is this theory true?" - it is how we determine whether our theories correspond truly with the laws of nature. While Maudlin does admit of a distinction between laws and theories in Lewis' account, he misunderstands Lewis' intended distinction. For Maudlin, since "an ideal epistemic agent…could, in principle, determine the laws," Maudlin ends up still equivocating between laws and true theories. The problem with the way Maudlin addresses Lewis' account of the laws of nature is that he holds it up as if it were a theory of laws of nature, when in fact it is a theory of scientific theories. The two problems, the ontological and the epistemological, are problems with the laws of nature, those that "nature respects". Since Lewis' account does not address these laws of nature but rather seeks to describe a theory of scientific theories (and criteria by which we can describe a law of science as such), Maudlin misrepresents Lewis' argument though of course without intending to.

3. Maudlin's Proposal on Laws of Nature

When addressing Armstrong, Maudlin seems to not realize that Armstrong and he are in reality arguing the same point, namely that laws of nature are ontologically primitive. In discussing the account of van Fraassen, Maudlin clearly distinguished between laws and theories, but only because van Fraassen forces his hand, so to speak. Faced with the position of Lewis, Maudlin equivocates between laws and

true theories. In his own account he seems to be equivocating between laws of nature and scientific theories *simpliciter*.

Perhaps the most striking example of Maudlin's lack of clear distinction between the laws of nature and scientific theories is in introducing his own account of the laws of nature. This begins immediately after critiquing Armstrong. I will cite it again (pg. 11):

> "An appropriate place to begin is with some real **scientific theories** rather than with cooked examples of the 'All ravens are black' variety. Let us look at some **laws** without formal prejudices and see what we find." [Emphasis added]

Maudlin seems to equivocate between scientific theories and laws. Granted this is just one example, but these are pivotal sentences that make a transition to the rest of the paper. He suggests beginning with "scientific theories." And he does then go on to describe scientific theories, but in his descriptions he consistently refers to them as laws, even fundamental laws.

As examples of laws, he gives "the fundamental law of Newtonian mechanics, F = ma" and "the fundamental law of non-relativistic quantum mechanics, Schrödinger's equation, $i\hbar\frac{\partial}{\partial t}|\Psi\rangle = \mathrm{H}|\Psi\rangle$." He goes on to explain, (pg 12)

> "The laws cited above, then, tell us how, at least for some period and in some region, physical states evolve through time. Standing alone they are incomplete, for we need principles for determining the forces in Newtonian mechanics and the Hamiltonian operator H in quantum theory. Newton's third law and law of gravitation supply part of this demand. But the principle of temporal change is the motor of the enterprise. Supplying a force function for electrical interactions, frictional forces, etc. yields instances of Newtonian mechanics. One can change the form of a force function but stay within the Newtonian regime. Changing the law of temporal evolution, though, constitutes a rejection of Newtonian mechanics. Similarly, Schrödinger's equation, without any further specification of the Hamiltonian operator, is considered a fundamental principle of quantum mechanics." (Maudlin 2010, pg. 12)

He calls them “Fundamental Laws of Temporal Evolution (FLOTES)” (Maudlin 2010, pg. 12). The force function or the Hamiltonian that must be defined further in order to more clearly describe the system he calls “adjunct principles”. He also points out there are “boundary conditions” which are necessary to describe the physical system. But it is the FLOTES, he says, which are primary.

This is problematic. These FLOTES are not fundamental laws of nature, but they are scientific theories, discovered by the minds of scientists. Principles of Newtonian mechanics or quantum mechanics like these are principles of scientific theories, which were developed and refined over the course of history. We do not know that they are the “patterns that nature respects” (Maudlin 2010, pg 15), and so we cannot say with certainty that they are laws of nature. Neither “F = ma” nor Schrödinger’s equation can be said to be fundamental laws of nature. On quantum scales, our experimental results agree with the predictions of Schrödinger’s equation, and certainly do not agree with Newton’s force equation. The electron orbitals of a Hydrogen atom can be beautifully predicted with Schrödinger’s equation, but they in no way follow from the force equation of Newtonian Mechanics. Many scientists would even say that Newtonian Mechanics and the F = ma “law” has been replaced by quantum relativistic mechanics.

In the next section, “The Modest Proposal,” Maudlin presents his proposal that laws of nature are ontologically primitive. The idea of primitive ontology as an attribute of a physical theory was first introduced in (Goldstein, 1998), and later developed by (Allori, V., Goldstein S., Tumulka, R., Zanghi, N 2008, 2011, 2013 , 2014). It is the idea that any physical theory needs to not only provide a mathematical model of the world and give good predictions, but also explain what exists and what is physically happening in the world. Those things which exist and to which things are physically happening are the ontological primitives. As mentioned in section II, Maudlin explains that ontologically primitive means “...not logically derived from, and cannot be defined in terms of, other notions.” (Maudlin 2010, pg 15)

Maudlin uses the phrase “physical ontology” in an article on quantum theory:

> “A physical theory should contain a physical ontology: What the theory postulates to exist as physically real. And it should also contain dynamics: laws (either deterministic or probabilistic) describing how these physically real entities behave. In a precise physical theory, both the

> ontology and the dynamics are represented in sharp mathematical terms. But it is exactly in this sense that the quantum-mechanical prediction-making recipe is not a physical theory. It does not specify what physically exists and how it behaves, but rather gives a (slightly vague) procedure for making statistical predictions about the outcomes of experiments. And what are often called "alternative interpretations of quantum theory" are rather alternative precise physical theories with exactly defined physical ontologies and dynamics that (if true) would explain why the quantum recipe works as well as it does." (Maudlin 2019)

If Maudlin is using the term ontologically primitive in the same sense as the way it has been used by Goldstein (the one who introduced the term) and Allori (one of his graduate students), then he means that the laws of nature are really existing entities, but he does not make any claims as to their physicality.

Maudlin's describes of his position that the laws of nature are ontologically primitive:

> "My own proposal is simple: laws of nature ought to be accepted as ontologically primitive. We may use metaphors to fire the imagination: among the regularities of temporal evolution, some, such as perhaps that described by Schrödinger's equation, govern or determine or generate the evolution. But these metaphors are not offered as analyses. In fact it is relatively clear what is asserted when a functional relation is said to be a law. **Laws are the patterns that nature respects;** to say what is physically possible is to say what the constraint of those patterns allows." (Maudlin 2010, pg 15) [Emphasis added]

This depiction of the regularity described by Schrödinger's equation as governing, determining, or generating the temporal evolution is disconcerting. There is no certainty among scientists that the theories they have discovered are correct - that would be the end of scientific discovery and search for better theories.

In addressing the epistemological question as to how to determine whether scientific theories are true representations of the laws of nature, Maudlin says the following:

> "To the epistemological questions I must, with Armstrong, admit a degree of skepticism. There is no guarantee that the observable phenomena will lead us to correctly infer the laws of nature." (Maudlin 2010, pg. 17)

This skepticism is appropriate, but it seems to be at odds with the way he has been treating scientific theories, as if they were accurate depictions of the laws of nature. If he does admit of skepticism, how can he give as examples of FLOTES "F = ma" and "$i\hbar\frac{\partial}{\partial t}|\Psi\rangle = H|\Psi\rangle$"?

With regard to the "epistemological questions", Armstrong is a bit of skeptic, but he does provide a clear criteria for establishing the epistemic status of scientific claims: Armstrong (1983) says,

> "I assume the truth of a Realistic account of laws of nature. That is to say, I assume that they exist independently of the minds which attempt to grasp them. (Just what sort of thing they are, it is the task of this essay to investigate. It is clear, simply from considering the typical forms of law-statements, that a law is some sort of complex entity.) Laws of nature must therefore be sharply distinguished from law-statements. Law-statements may be true or (much more likely) false. If they are true, then what makes them true is a law."

Armstrong clearly distinguishes here between "laws of nature" and "law-statements", which we are calling "scientific theories". This crucially important distinction seems to be lacking in many important places in Maudlin's chapter.

4. Conclusion

The purpose of this writing sample is to provide a critique of Maudlin's chapter. There are several places where Maudlin does distinguish between laws of nature and theories. To say he fails outright to make the distinction would be unfair. He omits the distinction, however, at crucial points in his arguments, which is the main argument of this short piece of writing.

One critique of my arguments is that they contend with Maudlin's writing of 13 years ago. Unfortunately, however, Maudlin's muddling of "theory" and "law" seems to pervade his language even

today. In a recent podcast (Maudlin & Erhardt Jan 2023), Maudlin tells the interviewer that the best physical theories we have contain the laws of nature that he considers ontologically primitive.

> Erhardt: "Granted that physics is incomplete, maybe it's something that can't be completed - I don't know. What are candidates for laws? When you talk about laws, what sort of things do you have in mind?"
>
> Maudlin: "Well, the best physical theories we have now are quantum theory and the general theory of relativity. Each of those have laws. In quantum theory, there's a law that tells you how the quantum state of a system evolves. That's Schrodinger's equation." (Maudlin & Erhardt Jan 2023)

To me this harkens back to the same sort of issues that I critique earlier in this paper.

The reasons I have for choosing one of Tim Maudlin's pieces of writings to critique were (a) because it was about the laws of nature, a topic in which I am very interested, and (b) because all that I have read written by Tim Maudlin and all the lectures I have heard by him have been exceptional. Having read several of his writings I eventually came across this one, in which I discovered several important problems. I bear no ill will towards Maudlin, and I only have the utmost respect for his work, specifically for his views on the laws of nature and quantum mechanics, which I admire and, for the most part, agree with.

We will have too high or too low expectations from our theories if we misunderstand the distinction. This is an area in the foundations of physics that I am very interested in studying further. Another area that I have discovered through studying Maudlin's work and that of his collaborators is the problem with so-called "interpretations" of quantum mechanics. Maudlin insists that we must not call them interpretations because they are actually different theories. Since each interpretation gives a different understanding about what the physical world is like, and physical theories tell us what the world is like, then we cannot relegate them simply to the level of "interpretations," as if they were of little importance to a physicist. If physicists disagree about what the world is like, they disagree about the very thing they study.

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