Constants of Nature, Law Construal, and Theory Individuation

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December 11, 2025

Abstract

The debate regarding whether physics requires absolute or merely comparative quantitative structure has surfaced a question regarding the nomological status of the constants: Are their magnitudes necessary or contingent? I argue here that this is merely a special case of a more general question: To what fineness of grain ought we construe the laws? Answering this question requires balancing the epistemic significance of the laws with the robustness of our standards for individuating theories. It is found that a relatively coarse-grained construal of the laws, making the constants nomologically contingent, best balances these considerations in a manner. To show this, a methodological primitivism is adopted, such that the laws are considered as equations, with differing degrees of structure. The interpretative equilibrium found construes the laws to have algebraic and polarity structure, but not magnitude structure. Not only is this of general significance for accounts of the laws of nature, but it also provides the contingentist comparativist an answer to accusations of fallacious theory equivocation.

Keywords: constants, laws of nature, quantities, modality, theories

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1 Introduction

Much ink has been spilled regarding the nature of the laws of nature. Much less has been spilled regarding the nature of our *construal* of said laws. I argue that this is in part due to a largely implicit dogma regarding one aspect of their construal. The dogma concerns the level of detail of the laws. Generally, the laws have been construed as fine-grained, they include the *magnitudes* of dimensional constants, e.g. the gravitational constant G. I will argue that the laws do not have such fine-grained structure—they are tolerant to possible variations in the magnitudes of the constants. The extent of this tolerable variation will be determined by a dialectic between a robust standard of theory individuation and modally significant laws. This issue is not only generally significant for our understanding of the metaphysics of laws but also has a more specific significance with respect to an ongoing debate regarding the structure of physical quantities—it favors a compartivist account of the metaphysics of quantity.

2 The Comparativist Tension

The metaphysics of quantity is a robust and growing subarea of the philosophy of science.[1] It has largely centered on a debate regarding the degree of quantitative structure physical science commits us to. The absolutists hold that the quantitative structure of physics includes specific magnitudes, such as what is referred to by “six kilograms” or “seven seconds”. The comparativists hold that the quantitative structure of physics does not require specific magnitudes, some less detailed structure, like quantity ratios (e.g. “twice as massive as”), is sufficient. The comparativists (most influentially Dasgupta 2013) have a symmetry argument against the existence or fundamentality of absolutist quantity structure: global scale symmetries, e.g. a universal mass doubling, is alleged to produce indistinguishable situations. However, a number of counterexamples have come to put pressure on the supposed comparativist symmetries (most notably those of Baker 2020). These counterexamples reveal that these symmetries, under the time evolution prescribed by the relevant physical laws, violate determinism. Alternatively put: these counterexamples show that comparativism “symmetry” transformations cannot both generate empirically indistinguishable situations and be consistent with the laws (Jalloh 2025).

At this point the debate diverges in a few different directions. I want to focus on the conversation concerning one particular comparativist rejoinder to the absolutist counterexamples.

[1]See Wolff (2020) and Martens (2024) for opinionated overviews of the field. I will not attempt to survey the full literature here.

This will bring us to main issue. Martens (2024) has dubbed this comparativist rejoinder "co-scaling".[2] Co-scalars argue, on basis of variously characterized symmetry considerations, that these supposed symmetry transformations, like mass doubling, are immune to such counterexamples when they are properly construed. Such basic quantity-scalings *induce* the co-scaling of dependent quantities like the gravitational constant. These full transformations do not violate determinism and are simultaneously empirical and dynamical symmetries.

Martens objects that the co-scalers have violated the rules of engagement, which include considering only the counterfactual where masses double *ceteris paribus*:

> It is, however, plainly wrong that the active Leibniz mass scaling is ill defined until we tell a story about G. We want to know if changing the masses leads to an empirical difference, *ceteris paribus*. Clearly that means keeping the (standard, absolutist) laws—including their 'strength', as represented by parameters such as Newton's constant—the same. It is not at all surprising that if one were allowed to change (the strength of) the laws at will for each possible world one could get any (or at least many) of the evolutions one may have wanted. That is simply not an option within the rules of the game we are playing. (Martens 2022, 335)

This means that changing the magnitude of a constant, like G, is *per se* a violation of the law. Therefore so-called comparitivist symmetries cannot be symmetries, and the absolutist counterexamples hold.[3]

This connects back to our main issue. Martens apparently holds that the content of the laws includes the magnitudes of the constants therein. This construal of the laws I call the fine-grained conception. The alternative conception, which the comparativist seems committed to, insofar as they accept the co-scalar solution, is the coarse-grained conception. A very close (though not quite identical) distinction was given by Jalloh (2025). He distinguished constant necessitism and constant contingentism: on the former, the magnitudes of the constants are nomologically necessary; on the latter, their magnitudes are nomologically contingent. The present distinction improves on Jalloh's in two ways: it focuses out attention on the laws and not the constants, and it allows for the consideration of ways in which laws may be construed finely or coarsely un a unified manner, as we will see.

[2]The murderers' row of co-scalars comprises Roberts (2016), Jacobs (2022), and Jalloh (2025). From personal communication, I know one member rejects the charaterization and another wholeheartedly accepts it. That is to say, while Martens' grouping and charaterization is not without controversy, I agree with it and it is accurate enough for my purposes here.

[3]I will simply state but not explain that this is a far more direct way of considering the possibility "comparativist laws", which is a strand of the debate found in Dasgupta (2013), Baker (2020), and Sider (2020).

It may appear that there is little keeping the comparativist from adopting a coarser construal of the laws. To accept that the "standard" construal of the laws is fine-grained and absolutist is to fight with both hands tied. On the contrary, Martens provides reason to stop the comparativist from taking the easy way out; they not only propose to violate the law but also to change *theories*:

> An exclusive scaling would change the strength of gravitation and hence turn a solution of Newtonian Gravity into something that is not a solution, or rather a solution of a similar but distinct theory with stronger or weaker gravitational dynamics (Martens 2022). But perhaps this is too narrow-minded a view of what counts as a theory (Jacobs 2022), and we should allow G to vary within a single theory. (Martens 2024, sec. 6.3)

Martens' question is our starting point. He puts the comparativist in a dilemma: either the so-called comparativist symmetries violate the laws or they involve changing the subject, by switching theories via altering the constants. My argument in this article is that this tension can be dissolved. The hitherto presupposed fine-grained conception of laws is flawed.

3 Methodological Primitivism: Laws as Equations

In order to elucidate the distinction between the fine-grained and coarse-grained conceptions of laws, I need to first introduce what I will call *methodological primitivism* regarding the laws. In the metaphysics of laws, the literature centers around two popular reductionist accounts of the laws, Humean and dispositionalist. Recently, a third, primitivist account has gotten some attention. Under this account the laws and their necessity are not reducible to any set of more fundamental (and possibly non-modal) facts. While my intervention here may have some consequences for this debate one way or another (or another), I wish to set aside this sort of metaphysical dispute.[4] I will, however, borrow the language of primitivism.[5]

Analogously, there are two central methodological approaches to the laws. Both are *methodologically reductive*, in that they attempt to take the language that the laws are given in and translate or interpret them in another language, before performing logical and

[4]Further, my methodological primitivisim is a natural fit with, but does not commit me to, the quantity primitivism criticized by Perry (2023). This is not to say, however, that what I develop here is consistent or inconsistent with any particular metaphysical reduction of quantities.

[5]For recent primitivist account and comparisons to other accounts of laws of nature, see Chen (2024).

metaphysical analyses on them. These approaches are the syntactic (i.e. logical) and semantic (i.e. model-theoretic) interpretations of the laws.[6]

My methodological primitivism differs from the syntactic approach, in that the syntactic approach reduces laws to logical arrangements of empirically defined terms. There is no such assumption in the primitivist approach. The laws are equations, which are contentful and conceptually structured, but there is no further claim as to where their content or form comes from. Alternatively, the semantic approach also assumes a particular, model-theoretic, formal interpretation of the laws that the primitivist approach does not commit to. We do not ask what structures quantities reduce to or what the truthmakers of quantitative claims are. The algebra or calculus used to express the equation itself is the bottom floor of formal interpretation.[7] I will provide something of a partial order of the structures which constitute an equation and use this partial order to elucidate the distinction between fine and coarse grain conceptions of laws.

Besides notions of arithmetic and quantity, one of the most fundamental conceptual structures in an equation is the distinction between constant and variable. Such equations have *algebraic* structure. Constants are quantities that are invariant from system to system, while variables vary from system to system (and from time to time and location to location).[8] The algebraic form of an equation is determined by the arrangement of terms (related by addition, subtraction or equality) which are composed out of these two kinds of quantities, constants and variables. In physical equations, that is to say, equations about physical quantities, the quantities additionally have dimension. The dimensions of a quantity can be thought of as the more basic quantity kinds that it is made up of. An acceleration has a dimension of 1 in length and −2 in time; this is represented in dimensional equations like $[a] = \frac{[\mathrm{L}]}{[\mathrm{T}^2]}$. Insofar as an equation is representative of physical phenomena it should be unit invariant, and so it will satisfy the principle of dimensional homogeneity: all of its terms will have the same dimension.[9] Dimensional homogeneity is thereby a constraint on the algebraic

[6]For a history of these two interpretations and references, see Lutz (2017).

[7]This primitivism might be found to be similar to Wallace's (2022, 2024) math-first structural realism and Wilson's (2022) plea for philosophers to refocus on the *equations* of physics. We share (I believe), a desire to do metaphysics of physics in the natural ideology of physics. For another attempt to understand the *ideology* of physics, see Jacobs (2024). A full comparison of these approaches will have to be postponed.

[8]More elaborate taxonomies of the varying level of constants are given by Lévy-Leblond (2019) and Johnson (2018). In what follows, my concern is only with the higher orders of constants, i.e. dynamical or universal constants. These are the constants with possible metaphysical signifcance.

[9]For a defense of the need for unit invariant laws see Grozier (2020). For an argument against the link between unit invariance and dimensional homogeneity see Lange (2017). A response to this

form of physical equations, by providing a consistency condition on the terms of the equation (that they have the same dimension).[10]

Finer-grained structure than the dimensional structure of an equation includes the degree or rank of the quantities involved (i.e. what order of scalar, vector, or tensor they are), their polarity (i.e. positive, negative, or imaginary), and their magnitude—such structure does not figure in what I am calling the algebraic form of an equation. I will be ignoring differential structure and degree structure here.[11] I will also be ignoring imaginary quantities. I want only to provide a simple account of the different fineness of grain of polarity and magnitude here.[12]

Algebraic form, as determined by dimensional structure, underdetermines both the polarity and magnitudes of the quantities which appear in an equations terms. An equation is dimensionally valid whether all of its terms are positive or if some are negative. Further, polarity is a determinable property with magnitudes being its determinate. If the charge of the electron is essentially negative, the magnitude of the charge is still to be determined.[13] We might go further and say that magnitudes are also determinates of the determinables dimensions. This is essentially claimed by some important accounts of quantity (Wolff 2020; Mundy 1987) and follows naturally from the idea that cross dimensional comparisons of quantity are nonsensical (a particular reading of the principle of dimensional homogeneity). But we do not need to commit ourselves to that view here.

With this conceptual apparatus laid out, we can now give a more precise distinction to the two conception of laws. The fine-grained conception of laws construes laws as equations with their complete structure, including the magnitudes of constants. The coarse-grained conception of laws construes laws as equations with minimal structure, excluding the magnitudes of the constants. Note that on neither conception are the magnitudes of

class of objection can be found in Gibbings (2011). Other important philosophical works on the foundation of dimensional analysis include Sterrett (2009), Sterrett (2021), and Jalloh (2024).

[10] See Jacobs (2022) and Martens (2024) for functional models of the constants which makes this claim intuitive. Different magnitudes of a given constant result in different functions or mappings from the magnitudes of some quantity (say masses) to some other quantity (say forces), according to the form of the law.

[11] But see Dewar (2024).

[12] These different structures are not fully distinguishable in practice. In the mechanics, otherwise inscrutable quantities, like a negative velocity, are often interpreted as oppositely directed vectors. In such a case, polarity structure is interpreted in terms of vector structure.

[13] With ordinary usuage, magnitudes include polarity. "Absolute magnitude" refers to the polarity neutral size of the quantity. This obviously conflicts with the significance of the term in the absolutism-comparativism debate, and its use will be avoided.

variables construed to be parts of the equations; I take this to be definitional. One might immediately provide an objection to a coarse-grained construal of the laws, that it undermines the distinction between constants and variables. However, there remains a robust distinction, even on the coarse-grained conception, as the constants (of interest) are *global* while variables are *local*, varying from system to system. Even if we consider the universe as a whole as a system, the constants are thereby very special "variables", they cannot hold multiple values in one world, like variables can. Each set of constant magnitudes belongs to a disjoint set of possible worlds. We need not make any such modal appeal to interpret the possibility of different variables, e.g. velocities.

4 Theory Individuation

The absolutism-comparativism debate, as I presented it, left us at a dilemma for the co-scaling compartivist: either their co-scaled symmetries violate the laws or they are changing the subject. The co-scaled symmetries are taken to violate the laws if the laws are construed so as to include the magnitudes of the constants in their content—the fine-grained conception of the laws. If the comparativist escapes this by construing the laws in a coarse-grained model, they are accused of equivocating distinct theories. As alluded to before, it does seem to be the case that the fine-grained conception of the laws is a largely unspoken dogma. Beside Martens making it explicit, I can also appeal to the recent interest in the possible variation of the constants. It is often said that large scale variations in the constants would indicate that the laws themselves vary (see Duff 2002; Barrow and Webb 2005; Riordan 2015).[14]

Here I argue that the constraint on how theories construe the laws given by the fine-grained conception comes with grave costs to our modal epistemology. My *reductio* runs from epistemology to metaphysics and from theories to law: if it holds the coarse-grained construal of the laws is at least acceptable, if not required, allowing the co-scaling comparativist to avoid one major objection.[15]

I want to provide a minimalist account of how I see the relationships between laws and theories, on the one hand, and modal epistemology and modal metaphysics, on the other, in order to make this sort of argument. I take that we can distinguish between equations that are laws and equations that are not. These latter equations are usually derived from the laws

[14] It has also been recently argued that the constants somehow *identify* the laws by Dahan (2020). However, Dahan's notion of "identification" is epistemic, and may be consistent with different metaphysical construals of the laws.

[15] It is not clear, for example, that this avoids the objections of "kinematic absolutism", developed by Tricard (2025a, 2025b).

plus some initial conditions, boundary conditions, or mere variable fixings. These features are usually not considered to be universal to systems, and therefore equations derived from them cannot have the same degree of necessity as the laws do.[16] I take this distinction to be one we make *within* a theory. Any *construal* of the laws that makes this distinction impossible to *state* or *know* within a theory has foreclosed our most viable naturalistic epistemology of modality and so impoverished our possible methods for determining a modal metaphysics (Bryant and Wilson 2024). Worse still, we may consider that the reason we believe there are things such as laws at all is because we believe ourselves to be in possession of modal knowledge. Without such an explanatory purpose, it is hard to see how the issue of construing laws can even get off the ground. My claim is that the fine-grained conception of the laws puts us in such an epistemological crisis, with corresponding metaphysical consequences.[17]

To get deeper into the theory individuation issue we reconceptualize this debate in terms set by Bokulich and Bocchi (2024): these two conceptions are different positions on the "tolerance" or "quantitative resolution" of theories. Focusing again on the constants, the tolerance of a theory defines the amount of deviation the observed value of a constant may have from its theoretical value without the observed value being a "quantitative anomaly" (in the sense of Kuhn 1961). Alternatively, the question we are facing is: To what extent might the value of a constant in a theory range before we are dealing with a different theory? The coarse-grained and fine-grained conception represent two possible extremes in the construal of law.

The fine-grained conception results in a fragile theory, a theory that is falsified (or at least problematized) by any measured value of the constant that does not *exactly* match its predicted value—it has no tolerance.

[16] For more on the "suporting cast" of laws, see McKenna (2023) and Bursten (2021). Some such conditions, like the Past Hypothesis, have been elevated by some to the level of a law of nature (see Chen 2023 for a recent discussion). That *some* such conditions may be laws doesn't affect my argument.

[17] Besides a construal of the laws, there may be much else that is involved in the individuation of a theory. See Maudlin (2018) for a proposal for the "canonical presentation" of a theory.

G-parameter space on the Fine-Grained Conception

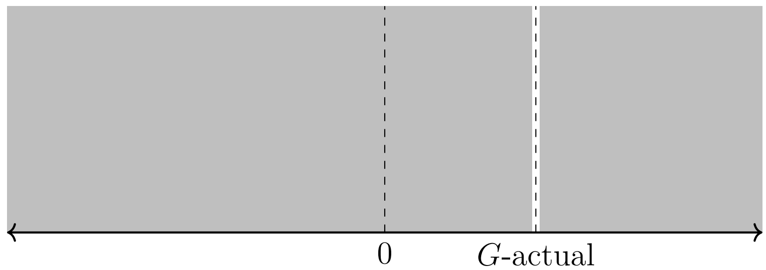

Figure 1: The permissible parameter space G according to the fine-grained conception of the laws. The grayed out area marks impermissible values for G, an extended buffer zone is included purely for readability.

In addition to the fragility problem, there is a modal discernability problem. On the fine-grained conception, ordinary counterfactuals and counterlegals (in which G varies a near infinitesimal amount) would be empirically indistinguishable, though they vastly differ in modal status. The most recent CODATA reccommended value for the gravitation constant is given to a level of precision of ten parts in a trillion (Mohr et al. 2025). However, if the quantities of physics are truly real valued,[18] then the magnitude of the constants are empirically underdetermined (and always will be). Therefore any such fine-grained construal of the laws will not be able to distinguish some class of counterlegals, where their magnitudes are differ below our level precision metrology, from the class of counterfactuals. That is to say: we cannot tell, in some cases, if the laws has been violated or not (or alternatively, if our theory has been falsified or not). This is a scandal for the epistemology of modality. While *a priori* methods may suffice for an epistemology of logical and metaphysical modality, the history of science is rife with examples of the failure of non-naturalistic guides to modality (or even misunderstood naturalistic guides)—consider the history of perpetual motion machines. In this case, one would not have sufficient grounds for describing an exact planetary orbit as possible, given the small room for error given by the low tolerance of the gravitational constant. As the laws are to be epistemic guides to and metaphysical explanations of such modal claims, this conception is methodologically untenable.

Also problematic is the coarse-grained conception, which is *too* tolerant. Any measured value of G would be consistent with the gravitational law.

[18]Which is not entirely uncontroversial, see Miller (2021). All I need is that it is not certain we have reached the bottom level of precision, if there is one.

G-parameter space on the Coarse-Grained Conception

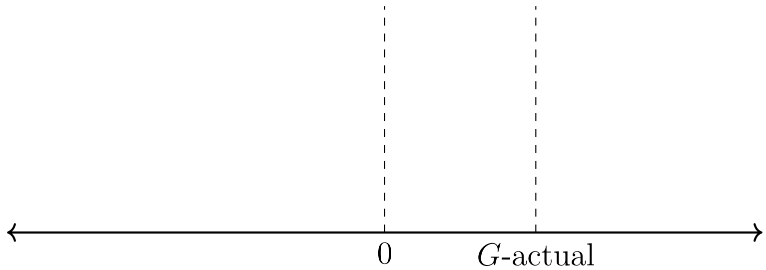

Figure 2: The permissible parameter space G according to the coarse-grained conception of the laws. There are no impermissible values for G.

This position too is untenable: no observed value of the gravitational constant could be considered an anomaly for Newtonian physics. This would have an especially embarrassing result if the constant was found to have an opposite valence than it is claimed to have, i.e. if the gravitational constant was negative instead of positive.[19] This would mean that the gravitational force manifests as a repulsive force rather than an attractive force—certainly this would be an anomaly given what we take the gravitational law to claim. More embarrassing still would be if the constant was found to have a zero magnitude, meaning there is no gravitational force—the law cannot be neutral on whether or not the force it describes has any magnitude whatsoever.

One might object that this is precisely the position we are in with respect to the cosmological constant. Theoretical constraints and current measurements put the constant as nearly flat (i.e. $\Lambda \approx 0$), but it could be either positive or negative depending on the curvature of spacetime. My remark here should be tempered then: what polarities it is "reasonable" for a constant to have (positive, negative, or zero) will be dependent on the theory and its stage of development. It is a big difference that Newtonian gravitation is essentially a theory of *attraction*, while general relativity is a general theoretical framework of spacetime curvature. We may reserve the notion of "theory" for the field equations combined with some claim regarding the large-scale or global curvature of spacetime.[20]

Both conceptions of the laws will need to be modified in order to be tenable: the coarse-

[19] I am here adopting the convention that the gravitational constant is positive and the negative feature of the gravitational law is a part of the algebraic structure of the law, rather than the polarity of some particular quantity—if you prefer the opposite convention just flip my usage of "positive" and "negative". Whether positive or negative values are associated with an attractive force is conventional.

[20] I thank an anonymous reviewer for raising this issue.

grained conception must have its parameter space narrowed and the fine-grained conception must have it's parameter space widened. I argue here that the modified coarse-grained conception is a natural extension of the original coarse-grained conception, while the modified fine-grained conception is ad-hoc; this should leads us to prefer the modified coarse grained conception. This can be made precise by considering the different orders of law construal considered in the previous section. The modified coarse-grained conception involves construing the laws as also having polarity structure, while there is no corresponding *structure* to be removed from the modified fine-grained conception that doesn't collapse into a species of coarse-grained construal.

Getting to the modified coarse-grained conception is simple: we constrain the parameter space of the constant to preserve its polarity and augment our conception of algebraic structure to include not just dimensional structure but also the number of terms. The law necessitates the dimensions and the polarity of the law, but not its magnitude (except for the extremal cases of 0 and ∞, which break the theory). The algebraic structure of the laws includes not only the proportionality relations but also the relative valences of the terms. This constraint on the coarse-grained conception amounts to saying that the valences of the terms involved are intrinsic to the law. If we briefly consider possible laws with multiple terms, it is clear that $F = ax + by$ is a different law (and so corresponds to a different theory) than $F = ax - by$. Dimensional homogeneity only requires that each term is homogeneous, what the relation (addition or subtraction) is dimensional irrelevant. We can alternatively define both sides of an equation generically as sums and then hold "inter-term relations" to be determined in the polarities of the constituent quantities of each term, rather than as an external relation. On either convention the modification of the construal of the laws is done on the basis of a structural feature of the equations, and not special pleading regarding the acceptable magnitudes of the constants.

G-parameter space on the Modified Coarse-Grained Conception

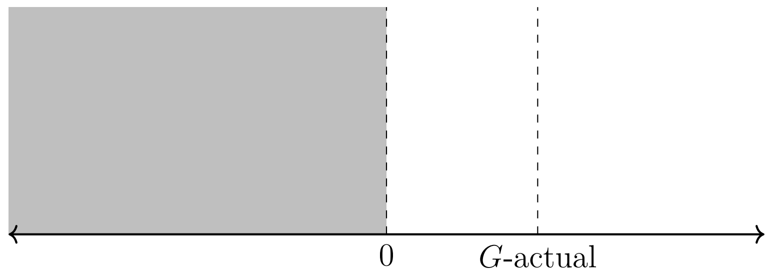

Figure 3: The permissible parameter space G according to the modified coarse-grained conception of the laws. The grayed out area marks impermissible values for G, adding a constraint to the maximal region set out in Figure 2.

In contrast, the constraints that we ought to put on the modified fine-grained conception are not clear. We ought to give our theories some tolerance, but how much is unclear—if we adopt the polarity constraint that we put on the modified coarse-grained conception, we get a model like the following.[21]

G-parameter space on the Modified Fine-Grained Conception

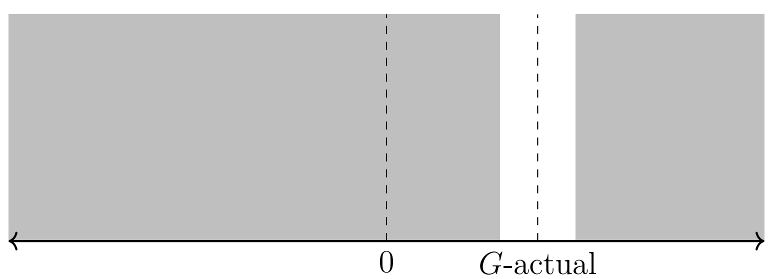

Figure 4: The permissible parameter space G according to the modified fine-grained conception of the laws. The grayed out area marks impermissible values for G, an extended buffer zone shows the wider permissible range compared to Figure 1.

One might make the case that the fact that the tolerance of the theory is not determinable *a priori* is a benefit to this account—it is through empirical research that we narrow the band of tolerance, thereby increasing the quantitative resolution of the theory (Bokulich and Bocchi 2024) or further confirming the theory by "closing the loop" and raising our standard of accuracy (Smith 2014). This then would lead to a dynamical view of the parameter space:

[21] Or rather a class of models with varying tolerance regions.

theories generally move from coarser-grained to finer-grained conceptions of their laws as empirical research develops.

The Dynamics of the *G*-Parameter Space

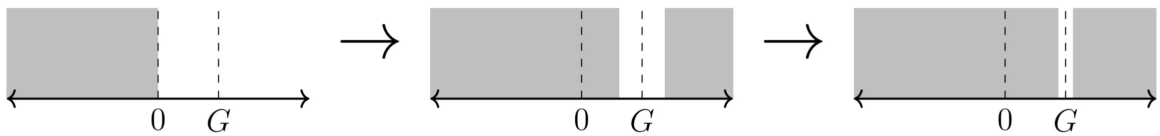

Figure 5: As measurements improve and develop, the tolerance of a theory narrows. Here the full range of the modified coarse-grained conception is shown to narrow to the range of the modified fine-grained conception.

Now it may seem that we've come to a nice compromise position, which takes seriously the role of measurements of the constants in our varying theoretical construals of the laws. However, this dynamical picture is really better understood as a variation of the modified coarse-grained conception of the laws rather than the modified fine-grained conception. Insofar as we adopt the simple dicohtmy of constant necessitism and constant contingentism from Jalloh (2025), we have both views have adopted constant contingentism. On the more detailed account of law construal developed here, only the modified coarse-grained conception can be justified on a structural basis. This means that the range of positive "impermissible" magnitudes in the dynamical picture have a different modal status than the negative impermissible magnitudes—the grounds of the impermissibility of those positive magnitudes are contingent. So we have a way to distinguish counterlegal and counterfactual variations in the constants.

How could this dynamical, empirically determined constraint be accounted for starting from the modified fine-grained conception? Perhaps the magnitude of the constant is necessitated, but the necessitated magnitude is vague, with its vagueness decreasing with time. This would mean that the laws themselves are vague. The possibility of nomic vagueness has been considered recently and is not beyond the pale (see Chen 2022), but this is a very revisionary conception to apply *generally* to quantitative laws. Further, it is not clear that this sort of vagueness fits any non-epistemic model of vagueness, if it can be decreased by empirical investigation. If our increasingly precise determminations of the magnitude of G somehow change its degree of vagueness in a metaphysical or physical sense, it is no longer a constant, but another variable. Giving a relatively unproblematic, metaphysical interpretation of the dynamics of the G-parameter space is a major challenge for the modified fine-grained conception, especially when there is an apparently adequate view (the modified coarse-grained view), that does not invite a host of concomitant issues.

5 Conclusion

The arugment between the comparativist and the absolutist leads to an apparent tension between the possibility of constants with different magnitudes and the indivduation of theories. I have here characterized this tension as a question regarding how we construe the laws. On a coarse-grained conception of the laws, the magnitudes of the constants are not part of the content of the laws and so are nomologically contingent. On a fine-grained conception of the laws, the magnitudes of the constants are part of the content of the laws, and so are nomologically necessary. Side constraints from the tolerance of theories and modal epistmeology necessitate the constraining of both of these construals of the laws, but only the coarse-grained conception admits of principled constraints from well defined structures in the equations we take to be laws. The comparativist may adopt an account in which the magnitudes of the constants are contigent, without adopting an overly liberal standard for theory individuation. In arguing for this, I have shown that an unremarked upon orthodoxy in our construal of the laws, the fine-grained conception, is untenable.

One final point: While originalism is not a recognized argumentative strategy in the philosophy of science, it is worth noting that the original conception of Newton's gravitational law was not fine-grained, as the orthodoxy would have it. Indeed there was no conception of the gravitational constant (and so no magnitude structure) at all:

> So, G did not appear until 200 years after Newton proposed his gravitational theory. Newton himself had not used symbolic equations at all: 'absolute forces of the attracting bodies A and B will be to each other as those very bodies A and B to which those forces belong' and 'The force of gravity which tends to any one planet is inversely as the square of the distance of places from that planet's centre' (3, Vol 1 Prop 69 Thm 29, and Vol 2 Prop 5 Thm 5 Cor II). By comparing the attraction of one planet to that of another, expressing the results as ratios, there was no place for a gravitational constant. (Falconer 2022)

This gives us some reason to believe that some species of the coarse-grained conception of the laws is closer to their core meaning and that the representation of laws by equations, for all its benefits, may be in some respects misleading.[22] This makes clear that methodological

[22] This is not to introduce a nihilism about constants as a further alternative view. To convert a

primitivism, with respect to the laws, can only serve as a starting point for their full interpretation.

proportionality to an equation one only needs to add a "constant of proportionality" which is free or empirically determined. This is just the same as the coarse-grained conception.

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