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Approximate Truth and Descriptive Nesting

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Abstract There is good reason to suppose that our best physical theories, quantum mechanics and special relativity, are false if taken together and literally. If they are in fact false, then how should they count as providing knowledge of the physical world? One might imagine that, while strictly false, our best physical theories are nevertheless in some sense probably approximately true. This paper presents a notion of local probable approximate truth in terms of descriptive nesting relations between current and subsequent theories. This notion helps explain how false physical theories might nevertheless provide physical knowledge of a variety that is particularly salient to diachronic empirical inquiry.

1 Description, Error, and Approximate Truth

It is customary to imagine that our best physical theories are true, probably true, or probably approximately true.[1] This view of the proper cognitive status of our best physical theories is well-expressed by Isaac Newton in Rule IV of his *Rules for the Study of Natural Philosophy*:

> In experimental philosophy, propositions gathered from phenomena by induction should be considered exactly or very nearly true not withstanding any contrary hypothesis, until yet other phenomena make such propositions either more exact or liable to exceptions. (Newton 1999, 796)

[1] Hillary Putnam echoes this sentiment in his characterization of scientific realism: when a realistically minded scientist accepts a theory "he accepts it as true (or probably true, or approximately-true, or probably approximately-true)" (Putnam 1979, 210).

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Newton allowed for the possibility that his mechanics might be made more accurate or liable to exceptions, but he did not believe that it was simply false. From our current epistemic perspective, whether Newtonian mechanics should be taken to be approximately true or radically false as a description of the physical world depends on what one cares about. In some ways, Newtonian mechanics might be understood to be a limiting case of our current best physical theories. On the other hand, Newton did not have the conceptual tools, involving such notions as *superposition* and *spacetime*, needed to express even the differences in how these theories describe the physical world. While Newtonian mechanics approximates our best current physical theories in some ways, it is only from the perspective of subsequent theories that one can say concretely how Newtonian mechanics may err in hitting the mark of descriptive truth.[2]

We find ourselves in an epistemic situation similar to Newton's with respect to our current best physical theories in that we do not yet have a perspective from which to explicate fully the senses in which they may hit and miss the mark of descriptive truth. Moreover, insofar as quantum mechanics and special relativity are foundational to our current best physical theories, the relativistic quantum measurement problem provides good reason, by virtue of the structure of the physical theories themselves, to suppose that our best physical theories are false. In this sense, the proper epistemic status of our current best physical theories is particularly puzzling.[3]

The relativistic version of the quantum measurement problem is that the standard von Neumann-Dirac collapse formulation of quantum mechanics seeks to explain why one should expect to get determinate physical measurement records in a way that is logically inconsistent on a strict, uncharitable reading and both descriptively incomplete and incompatible with the constraints of relativity on even the most charitable reading. Further, it is unclear how one might modify quantum mechanics, relativity, or both in order (*i*) to account for our having determinate physical measurement records and (*ii*) to satisfy the constraints of relativity. Insofar as the standard collapse formulation of quantum mechanics and special relativity are logically incompatible, the two theories taken together are false; and since we do not know how to account for determinate measurement records subject to relativistic constraints, we do not know how they miss descriptive truth.[4]

While there are many proposals for resolving the relativistic quantum measurement problem, they differ in where they locate the descriptive failures of our current best physical theories, and hence differ in the sense in which they may allow for our

[2] See Barrett (2003) for a discussion of this point.

[3] That particular physical laws, theories, and models must be considered false is a recurring theme in the philosophy of science. See Cartwright (1999), Sklar (2003), Barrett (2003), Teller (2004), and Frisch (2004) for recent examples. The reasons for judging a particular law, theory, or model to be false vary. The relativistic quantum measurement problem is particularly troubling insofar as one is committed to both relativity and quantum mechanics eventually providing the basis for a unified description of the physical world at some level.

[4] See von Neumann (1955) for a description of the standard collapse formulation of quantum mechanics and Barrett (1999, 2003), Albert (2000), and Maudlin (2002) for more details concerning the relativistic version of the quantum measurement problem.

current physical theories to be judged approximately true. As relatively simple but representative examples, the GRW formulation of quantum mechanics (Ghirardi et al. 1986) suggests that the standard linear dynamics is only approximately true since it lacks a stochastic term that explains spontaneous collapses of the quantum-mechanical state, while Bohmian mechanics (Bohm 1952) suggests that the standard collapse theory misses descriptive truth in allowing for collapses of the quantum-mechanical state at all; and both of these nonstandard formulations of quantum mechanics would require a significant change in our understanding of the descriptive content of special relativity in order for one to argue that either is compatible with relativistic constraints.[5]

If the standard collapse formulation of quantum mechanics and relativity are almost certainly false taken together and if, since we do not know how to fix them, we do not know the sense in which they can be taken to be approximately true, then in what sense do our current best physical theories provide physical knowledge? One reason that this is puzzling is that plausible candidates for physical knowledge are not far to find. Contrary to appearances, the sun is much larger than the earth and moon. The earth, as Galileo insisted and the Church denied, revolves about the sun and not the other way around. Most of the earth's surface is covered by water. Water is composed of discrete molecules that are themselves composed of two hydrogen atoms attached to one oxygen atom. Hydrogen and oxygen atoms are in turn composed of more fundamental particles. Among these are protons, neutrons, and electrons. Electrons are less massive than either protons or neutrons by a factor of more than one thousand. And so on.

A natural suggestion for how such physical knowledge is possible is that the commitment to descriptive truth here is purchased at the cost of descriptive imprecision. When we judge that Galileo was right and the Church was wrong, we presumably do not take Galileo's assertions to be true precisely as he understood them. Galileo was called before the Inquisition because he held, taught, and defended the claim that "The sun is the center of the world and immovable and that the Earth moves."[6] If one understands Galileo as claiming precisely that the sun is stationary, at the center of the universe, with the earth revolving around it, then we cannot agree with Galileo. So when we agree that the earth revolves about the sun and not the other way around, it is presumably that we take it to be easier to find truths in the context of subsequent theories of celestial mechanics that are recognizable as translations of the former claim, and perhaps that we expect this to be so for our future best theories as well. More specifically, insofar as we take our current account to eliminate previous descriptive errors concerning celestial mechanics and insofar as we take Galileo's position to be more readily translated into our current descriptive theories, we take Galileo's position to be closer to the

[5] Both GRW and Bohmian mechanics have dynamical laws that presuppose a preferred inertial frame. For GRW this is the frame in which the collapse occurs; and for Bohmian mechanics this is the frame used to characterize the (3*N*-dimensional) *N* particle configuration space. See Albert (1992) for a description of GRW and Bohmian mechanics and Barrett (2005) for a discussion of the sort of descriptive sacrifices one would have to make in order to construct a relativistic hidden-variable theory.

[6] See de Santillana (1955, 223) for the charges against Galileo. See Galileo's *Letter to the Grand Duchess Christina* in Drake ed. (1957) for an example of his defense of his position.

descriptive truth than the Church's position. From this perspective, it is the descriptive imprecision of Galileo's position from our perspective and the flexibility that we are willing to allow in our current and future interpretation of it that provides our continuing confidence in its truth. But there are also limits to such interpretational flexibility. While neither Galileo nor the Church would have understood the relevance of this to their respective claims, if it had turned out that the earth were much more massive than the sun, then Galileo would have been wrong and the Church right.

Returning to our own epistemic situation, we do not know the sense in which quantum mechanics and relativity will be taken to be approximately true after their descriptive infelicities are addressed. Indeed, it is a feature of our commitment to the elimination of descriptive error in diachronic inquiry that if we knew how our current theories will be judged to miss descriptive truth, we would fix them now.[7] Given the difficulties encountered so far in trying to resolve the relativistic quantum measurement problem, one might suspect that it is unlikely that we currently have even the conceptual tools that will later prove necessary to characterize our current descriptive errors. But, in any case, to begin developing such conceptual tools is to begin the work of constructing the next generation of theories. And what we accept as the next generation of theories will determine the sense in which we will take our current theories to have been in error. Providing a concrete local understanding, relative to subsequent theories, of the senses in which our current physical theories can be preserved and must be judged to be in error, and hence the senses in which they will be judged to have been approximately true, is a task for ongoing empirical inquiry, not current philosophical reflection. One might nevertheless seek to better understand the general nature and role of our commitments in diachronic inquiry to the local probable approximate truth of our current physical theories.

2 Local Approximate Truth and Descriptive Nesting

The investigation of notions of truthlikeness began in earnest with Karl Popper's (1963) account of verisimilitude. While Popper believed that scientific theories are never verified, he also took scientific inquiry to be epistemically superior to other forms of inquiry. Popper sought to explain this epistemic virtue by giving an account of the truth content of a theory.[8] More generally, the desire for a satisfactory notion of truthlikeness is typically a consequence of recognizing, for whatever reason, that our current best theories are false yet wanting an account of scientific progress. Such a notion is particularly salient if one takes our best current theories to be false and takes descriptive truth to be the proper aim of inquiry. If one can characterize what it is for a theory to bear a particular degree of proximity to the truth or even what it is for one theory to be closer to the truth than another, then one

[7] See Barrett (2003) for a discussion of this point.

[8] See Tichý (1974), Hilpinen (1976), Oddie (1986), and Zwart (2001) for further developments of Popper's notion of verisimilitude.

might use such notions to characterize scientific progress as progress toward the truth.[9]

The approach here is the other way around. Rather than characterize scientific progress in terms of increasing truthlikeness, the proposal is to start with the pragmatic view that inquiry involves the elimination error, then to use this understanding of inquiry to characterize a local notion of approximate truth in terms of descriptive nesting relations between our current best physical theories and subsequent theories. Such nesting relations will hold insofar as subsequent theories are understood as refinements of our current best theories that eliminate descriptive error.[10]

While one should expect subsequent physical theories to require an understanding of the physical world in some ways incommensurate with our current understanding, one should also expect that much of our current understanding concerning how to make reliable empirical predictions and how to explain physical phenomena will be preserved. There is a standing explanatory demand on future physical theories that they should characterize the descriptive errors as well as account for the predictive and explanatory successes of our current theories insofar as possible given other desired virtues.[11] After all, that our current theories are descriptively false but both empirically and explanatorily successful is something that calls for explanation. When available, relatively rich explanations of this feature of our current theories can be given in the context of descriptive nesting relations characterized by the descriptive features of our current theories preserved in subsequent theories and the senses in which those features are preserved. Sufficiently rich descriptive nesting relations between current and subsequent theories provide the sense in which the former theories may be judged to have been approximately true relative to the physical description provided by the subsequent theories, theories constructed specifically to eliminate descriptive error.

So what should one expect to be preserved between current and subsequent theories and how? One might expect successful empirical predictions, existence claims of physical entities successfully used to explain and predict phenomena, or perhaps claims concerning physical properties or relational structures, in particular those involved in successful explanation and prediction, to be preserved. While the

[9] See Niiniluoto (1987) and (1999) and Kuipers (2000) for examples of truthlikeness used in the defense of realist views of scientific progress.

[10] This approach to approximate truth and the discussion of guiding principles later in the paper fit well with a pragmatic account of truth akin to that of C. S. Peirce. On such an account, truth is descriptive of the world and is approached through diachronic inquiry by the elimination of error from our current best descriptions. That there are objective matters of fact can be thought of here as a precondition for the possibility of our current descriptions being in error and as the ground for a commitment to methodological fallibilism. Similarly, that error can be remedied through inquiry can be thought of as a precondition for the possibly of inquiry. Guiding principles represent higher-order commitments concerning how to make local progress in inquiry (e.g. Peirce 1877 and 1878).

[11] I take this to be a demand that is negotiated together with the desire for increased descriptive precision and the elimination of descriptive error in the next generation of theories. If no such descriptive nesting were satisfied, then it would be impossible to recognize the next generation of theories as providing a refined description of the world that remedies error. Rather, they would look like an abrupt change in subject.

history of physics provides examples of empirical, entity, and structural preservation in subsequent theories, it also provides plausible counterexamples for each sort of proposed preservation.[12] The most honest answer concerning what will be preserved in theory change and the sense in which it will it be preserved is that we typically do not know. Indeed, given the logic of empirical inquiry, we cannot know without at least beginning the construction of the next generation of theories, since knowledge about what will be preserved is knowledge of the features of subsequent theories. And it is only after we have accepted the subsequent theories as providing more accurate physical descriptions, that we can determine precisely what has and has not been preserved and how. The way that this plays out in a particular historical case will depend on the details of the theories involved and the specific errors addressed by the subsequent theories.

Consider, as a well-studied example, the relationship between Newtonian gravitation (NG) and the general theory of relativity (GTR).[13] In at least one sense, the descriptive explanations provided by the two theories could not be more different. According to NG, a projectile *P* would follow an elliptical trajectory about a more massive object *O* because *P* is accelerated by a gravitational force proportional to the masses of the two objects

$$\frac{-Gm_p m_o}{\vec{r}_{po}{}^2}.$$

If there were no forces acting on it, the projectile would either remain at rest or follow a straight trajectory, so its elliptical motion requires one to postulate just such a gravitational force. According to GTR, however, in this physical situation *P* would follow an unaccelerated, locally straight trajectory, a geodesic in spacetime, precisely because it is not subject to any forces whatsoever. On this revised description, it is an object at rest in a gravitational field that would be subjected to a force (the force one feels on the bottom of one's feet while waiting in line at the Department of Motor Vehicles, say) because an object not in freefall *is* accelerated. Insofar as these descriptive explanations of projectile motion are flatly contradictory, there is at least one sense in which the description of projectile motion provided by NG is not even approximately true from the perspective of GTR.

On the other hand, NG and GTR also share descriptive similarities. To begin, in many salient physical situations, the two theories make similar empirical predictions. If this were the only descriptive similarity between the two theories, then the cost of claiming that NG is approximately true from the perspective of GTR would be to identify the semantic content of the two theories with their empirical predictions. There are, however, richer senses of descriptive nesting between the

[12] While descriptive nesting between subsequent theories typically involves all three aspects of description, one of the three is sometimes better preserved than the others in a particular historical case. I take this to be why would-be positivists (instrumentalists, and such), entity realists, and structural realists can always find historical examples that they take to support their own views and to undermine the views of their opponents in the other camps.

[13] See Ehlers (1983) and (1991) and Malament (1986a), (b), and (2006) for detailed studies of the relationships between Newtonian mechanics and general relativity.

two theories, at least some of which can be characterized in the context of geometrized Newtonian gravitation (GNG).

GNG can be thought to occupy a descriptive middle ground between NG and GTR. In agreement with GTR, gravitation is not a force in GNG, but rather, is a manifestation of spacetime curvature.[14] Translating a description from NG to GNG, is a matter of translating a description of gravitational forces into a description of the corresponding geometric structure of a curved spacetime. This is most readily accomplished with a bit of reverse engineering. The trick is to ask what the geometric structure of spacetime would have to be in order for a geodesic, a locally straight trajectory, in GNG to agree with the accelerated trajectory predicted by the gravitational field equation and dynamics in NG. There is a unique differential operator $\overset{g}{\nabla}$ that characterizes the spacetime structure of GNG such that a timelike trajectory satisfies the equations of motion of NG if and only if it is a geodesic with respect to $\overset{g}{\nabla}$.[15] It is also possible to work the other direction and show that there typically exists at least one Newtonian potential that satisfies Poisson's equation, the field equation for the gravitational field in NG, and that captures the geodesics of GNG as accelerated trajectories in NG.[16]

The descriptive middle ground provided by GNG also allows one to compare and contrast the gravitational field equations of NG and GTR. Poisson's equation, the field equation in NG,

$$\nabla^2\phi = 4\pi\rho$$

where ϕ is the Newtonian gravitational potential and ρ is the Newtonian mass density, translates in GNG to

$$R_{ab} = 4\pi\rho\, t_{ab}$$

where R_{ab} is the Ricci tensor field and t_{ab} is the temporal metric. Einstein's field equation in GTR is

$$R_{ab} - \frac{1}{2}R\, g_{ab} = 8\pi\, T_{ab}$$

where R is the Riemann scalar curvature field, g_{ab} is the metric, and T_{ab} is the energy-momentum tensor field. For empty spacetime, where $T_{ab} = 0$, the field equation of GTR is $R_{ab} = 0$, which is precisely the GNG translation of Poisson's equation when the mass density is zero.

The relation between field equations in GNG and GTR are so descriptively close in this sense that Malament is led to suggest that although GNG was discovered well after GTR, it nonetheless provides "by far the best route" from NG to the GTR field equation for empty space, and he asks what could be more natural than to "start with the Newtonian empty space equation ($R_{ab} = 0$) and then simply leave it intact!" (2006, 19). Here there is a precise sense in which the gravitational field equation of GTR is just the field equation of NG for empty space.

[14] See Malament (2006, 40).

[15] This is a consequence of the Trautman-Malament geometrization theorem. See Malament (2006, 40–41).

[16] This is a consequence of the Trautman-Malament recovery theorem. See Malament (2006, 42–43).

GNG also provides the context for characterizing a special sort of descriptive nesting relation between NG and GTR: GNG, with the geometrized version of the Poisson's equation, is a limiting form of GTR, with Einstein's field equations, in the strong sense that one can specify a one-parameter convergence of GTR to GNG as relativistic effects become negligible. This convergence can be thought of as a geometric process where the relativistic light cones at each spacetime point in a solution of Einstein's field equation are flattened so that in the limit they are all tangent to a family of hypersurfaces, each of which represents a three-dimensional space at a time. The flattening of the light cones in this process has a natural physical interpretation as the gradual easing of relativistic constraints. Insofar as this light-cone flattening process is subject to the constraints of the field equations of GTR at every step, the resulting spacelike hypersurfaces will be spatially flat. And, in this same limit, the geometrized version of Poisson's equation is the limiting form of Einstein's field equation. So, in this sense, one can take GNG to be the limiting description of the world described by GTR as one gradually eases relativistic constraints. Since geometric descriptions in GNG are translatable into force descriptions in NG, this provides an especially compelling sense in which NG might be said to be approximately true from the perspective of GTR.

Each of these descriptive nesting relations provides a precise sense in which one can take a feature of NG to have been preserved in GTR. One might then *in these precise senses* judge the descriptions provided by NG to be approximately true from the perspective of GTR. And, insofar as GTR represents an elimination of descriptive error, the expected preservation of each of these features is presumably part of what Newton *should have wanted to mean* in claiming that his account of gravitation was at least approximately true. Of course, Newton could not have meant anything so precise without knowing what it would take to translate between descriptions in NG and descriptions in subsequent theories, and he did not know this. But he might well have meant for his claim of approximate truth to have served as a promissory note for descriptive nesting relations that he could not specify. And it is possible that, had he lived to learn how GTR describes the physical world, Newton might have recognized these nesting relations as a partial, tentative fulfillment of the intended promissory note. In any case, we are certainly free to do so.

While one would not expect the specific details of the descriptive nesting relations between NG and GTR to carry over to cases involving other physical theories, the relations between NG and GTR illustrate some very general features that one might expect to find elsewhere. First, while there are senses in which NG and GTR involve radically different descriptive explanations, there remain salient similarities in their descriptions of the physical world that go well beyond their shared empirical predictions. Malament's suggestion that one might simply adopt the geometrized Newtonian field equation for empty space as the field equation for empty space in general relativity provides a striking example of how close the descriptive content of the two theories is in at least one precisely specifiable sense. Second, since there are several ways in which one might compare and contrast the descriptive proximity of NG and GTR, there is no single canonical sense in which NG is approximately true relative to GTR. Hence, general claims concerning descriptive proximity that do not carefully characterize the sense of similarity or difference are empty. Third, one should expect the descriptive nesting relations between current and subsequent physical theories to be nontrivial. It would have been impossible to know precisely what would be preserved of NG and how without knowing how subsequent theories would be constructed. The rich descriptive nesting relations between NG and GTR discussed here are mediated by GNG, which was reverse-engineered using lessons learned from the construction of GTR. And finally, descriptive nesting relations, when we have them, can be expected to help explain both explanatory and predictive successes and failures of older theories relative to newer theories. The one-parameter convergence of GTR to GNG and the geometry-to-force translations between GNG and NG, for example, explain both the predictive and explanatory successes of NG in the sense in which the predictions and explanations of GTR converge to those of NG as relativistic effects become negligible, and the geometric structure that is washed out in this convergence provides one precise characterization of the descriptive errors of NG.

Insofar as the next generation of theories is taken to have eliminated specific descriptive error from our current theories, the next generation of theories is taken to be closer to the descriptive truth in the specified sense. While this local standard falls short of providing a total ordering of theories with respect to their proximity to the truth, it does fit with a pragmatic notion of progress toward the truth through the elimination of descriptive error. That there be a descriptive nesting relation between our current theories and the next generation of theories is a precondition for understanding the next generation of theories as refinements of our current theories. And the descriptive nesting relation that obtains provides the context for characterizing the local sense in which error was eliminated.[17]

3 The Reflective Role of Beliefs Concerning Descriptive Nesting

While we do not know precisely what descriptive errors will be remedied by future physical theories, one may nevertheless have more or less imprecise beliefs concerning what descriptive features of our current theories might be preserved and perhaps even how they might be preserved. One should expect such beliefs to guide in the construction of the next generation of physical theories; and insofar as it is desired that some particular set of descriptive features be preserved, one should expect the evaluation of subsequent theories to depend in part on the extent to which these theories are judged to have captured these features. In turn, however, the degree to which one believes that some descriptive feature will in fact be preserved will invariably be revised in light of evidence concerning the relative difficulty of

[17] That there be some sort of descriptive nesting is a standing demand, but the sort of nesting that obtains is negotiated in theory construction and selection with the aim of eliminating descriptive error. This process is less a cost-benefit analysis between competing ready-made theories and more a negotiation within the activity of constructing theories to construct those that can be recognized as refinements of current theories that eliminate descriptive error. Toward this end, theories are constructed that satisfy a descriptive nesting relation while eliminating descriptive error.

successfully incorporating it into the next generation of theories. If it cannot in fact be successfully incorporated, it will eventually be discarded as a descriptive error.

In order for a belief to serve as a guiding principle for empirical inquiry, it must be taken to be sufficiently imprecise as to be translatable as true in the context of theories that will, at least in some ways, differ radically from our current theories in their descriptions of the physical world; but it must also be taken as precise enough to act as a guiding constraint on the construction of these theories. Both the semantic content of the guiding principle and whether it can be maintained at all are contingent on the negotiated construction of the next generation of theories. This is the reflective role of beliefs concerning descriptive nesting. Such negotiated guiding principles might take the form of conservation or symmetry principles (while it clearly served as a constraint in the formulation of special relativity and while there are certainly similarities in semantic content, the principle of the conservation of energy also ends up meaning something saliently different in special relativity than what it meant in Newtonian mechanics), beliefs about the existence and nature of types of physical entities (the commitment to the existence and properties of electrons might be expected to inform our best relativistic field theories even if fields are ultimately taken as fundamental in future theories and particles are taken to be nothing but manifestations of local field properties), or commitments to particular laws (the standard unitary quantum-mechanical dynamics was essential in formulating Bohmian mechanics, but has a new significance in this context since, rather than describing the evolution of the superposition of configurations of a system that typically has no determinate configuration, in Bohmian mechanics it is part of the description of how the always-determinate configuration of a system evolves).

Insofar as it is difficult to imagine how any future account of celestial motion might render the Church's position closer to the truth than Galileo's, one might take Galileo's claim that the Earth revolves about the sun to be descriptively imprecise but nevertheless true. Also probable are conservation and symmetry principles, beliefs concerning the existence and properties of types of physical entities, and commitments to particular physical laws or descriptive models. But in order to count as probable, one must allow the precise semantic content of these claims to drift as we seek to eliminate descriptive error. Just as the conservation of energy has a somewhat different semantic content in special relativity than in Newtonian mechanics, the conservation of momentum may have a somewhat different semantic content in the context of a resolution to the relativistic quantum measurement problem insofar as, for example, in a hidden-variable formulation of quantum mechanics like Bohmian mechanics the conservation of momentum most naturally translates to a principle concerning conservation of *observed momentum*.[18]

It is typically only by allowing for some flexibility in our future understanding of what a particular guiding principle might mean that one can take it to be probably true; but, at the same time, insofar as such commitments are taken to constrain empirical inquiry, there are limits to how flexible one will be in future

[18] See Barrett (2000) for a discussion of the sense in which momentum is and is not conserved in Bohmian mechanics.

interpretations and translations of the principle. It is in this sense that our commitment to current features of our theories being preserved both reflects our commitment to these features representing local approximate truth and constrains the construction of the next generation of theories by proposing features we expect to be preserved. How our beliefs concerning what descriptive features of the world will be preserved and the senses in which they will be preserved to guide empirical inquiry reveals the nature and degree to which we have an epistemic commitment to their local approximate truth. The results of inquiry will determine whether or not our proposed constraints on descriptive nesting relations between current and subsequent theories will in fact be satisfied.

4 Conclusion

The pragmatic proposal here is that much of our physical knowledge resides in our beliefs concerning what descriptive features of our current physical theories we will judge to have been preserved in subsequent theories. Such beliefs will vary in probabilistic degree, in the type of preservation one expects, and in the precision to which one can express the commitment. As beliefs concerning expected preservations, they will act as guiding principles in the construction of subsequent theories. Those descriptive features of our current theories that are in fact preserved in subsequent theories will be taken to have been approximately true in the local sense in which they are preserved. Knowledge of local approximate truth then is knowledge concerning what will in fact be preserved and how it will be preserved in inquiry under the elimination of error.

Returning to our current epistemic situation, insofar as we take quantum mechanics and relativity to provide the conceptual starting point for the construction of the next generation of physical theories and to represent specific constraints on this construction, we also take them to provide such local physical knowledge. But we will only know the precise content of the local knowledge they provide when we know the descriptive nesting relations that will hold between our current and subsequent theories. This is the sense in which the local knowledge provided by our current best theories is both essential to and inseparable from diachronic empirical inquiry.[19]

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