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Hegel's Notion and Physical System Specification in Quantum Mechanics

1. Framing the Question

Rarely does a present-day philosopher of natural science make reference to, let alone engage with, the views of Kant and Hegel. These titans of German idealism devised the systems that are deemed relevant to the philosophers of mind, moral philosophers, logicians, and, as is often the case with Hegel, political philosophers. Despite Kant's attempt to balance pro-Newtonian deterministic views with the notion of the freedom of the will, it is hard to think of an immediate coherence among the topical issues of the philosophy of science, such as the quantum mechanical measurement problem or the monotonic behavior of thermodynamic properties, to the framework of Kant's mind theory governed by the schema of *a priori* categories, or to Hegel's dialectical, timeless quest of Geist to know itself, as presented in his phenomenology. To a large extent, the analytical philosophy born in early-twentieth-century Britain and initially fueled by positivism is viewed in opposition to the "synthetic" philosophy that obtained its utmost sophistication in German idealism.

This paper claims that such a connection exists and is relevant. Hegel saw his initial philosophical project warranted by the need to redefine the nature of rationality, or the nature of reason. His system is a response to the skepticism of Hume, the system elaborated on and modified by Kant, whose approach Hegel thought was still too skeptical. Aside from wanting to prove that human reason can be and is the tool for acquiring knowledge, he also engaged us in the discussion of whether the idea of the whole is superior to the atomistic[1] and reductionist

[1] As an aside, let me provide the relevant modern definition of atomism: it is to be viewed as the ability of phenomena to be decomposed into their constituent parts and for the whole to be able to be *fully* defined through the

proclivities of his predecessors for its ability to account for world phenomena. I argue that this is so in that his investigation runs a close course with the philosophy of science of the present.

The link is best established by examining how Hume and Kant, on the one hand, and Hegel, on the other, viewed the unity of objective matter. Simply put, how do humans define objects for what they are? I will argue that the Humean-Kantian assembler-mind approach leads to the necessary attribution of the ontological primacy to the object's constituent parts and therefore gravitates toward a reductionist view of matter, whereas Hegel views the category of *individual* as lacking self-identity, requiring the *particular* and the *universal* properties to be specified for an individual object to be what it is. Taken to the limit, Hegel's approach holds that the complete definition of anything will require the specification of the universe as a whole, thus making it ontologically irreducible. A modern rephrasing of the question could take the following form: can a physical system be *completely* specified by its constituent parts together with their spatio-temporal relations?

I will illuminate the playing field and the consequences of either approach by running parallels with the topical issue of the foundations of physics, the specifications for quantum mechanical systems. The discussion will touch upon some technical aspects of properties of such systems. I will strive not to lose the reader in the field-specific jargon.

2. Historical Perspective

The question of object ontologies was not new to philosophy when the German idealists began to tackle it, having started in fact with the holistically minded Aristotle. Locke and Hume

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properties of the parts. Whether we are defining a metaphysical noumena or epistemically accessible phenomena is irrelevant at this point.

were significant contributors to the discussion. Locke, in his attempt to determine what makes an object itself, introduced a category of *real essence*, viewing it as an intrinsic property of an object and contrasting it with the notion of *nominal essence*, its empirical appearance. Real essence, per Locke, is where the unity lies. It is unclear, however, how the unity brings itself about or is brought about.

Hume took the position at the opposite end of the spectrum, asserting that an object is but an assembly of multiple simple perceptions. Associative relations of resemblance, continuity in time and space, and causal relations bind these perceptions together in the mind of a human. Hume was skeptical of the question of how this explanation would account for why we find some objects invariably to have the same properties. This question was left for his followers to interpret.

Kant referred to and gave credence to Hume's ideas in *Critique of Pure Reason*. In Kant's view, Hume "recognized that in order for us to be able to [have cognition of an object], the origin of concepts must be *a priori*. But he [Hume] was unable to explain how it is possible that concepts not in themselves combined in the understanding should nonetheless have to be thought by it as *necessarily* combined in the object (CPR, A94)."

In expanding Hume's position, Kant outlined specific ways in which a human mind assembles various intuitions about objects into a unity. He famously did this by introducing the notions of *concepts* and *categories*. Concepts are what we perceive about the object and are intuitive (e.g., rock being warm). Categories are a specific set of relations that are granted as *a priori* properties of the mind. Concepts are reflected upon this grid of categories, then identified and assembled into judgments.

An example of a built-in *a priori* property would be our understanding of causality as being hardwired, so to speak, in our minds. Rock is warm because the sun shines on it; once we identify the intuitions (“warm” and “sun shines”), we do not need any additional input in bringing the two together. Making judgments of this sort allows us to extend our knowledge about these objects, and this knowledge extension is what constitutes the act of thinking. The process of adding chunks of knowledge construes, in Kant’s parlance, the so-called *synthetic judgments*.

Further, Kant spends an inordinate amount of time defining the concept of *unity*. What indeed does bring all intuitions together to form a unified experience for us? The object’s unity is not a simple linear addition of random perceptions by the mind. Kant defines two kinds of unity: a *subjective unity* (synthetic unity of apperception) and an *objective unity* (transcendental unity of apperception). In *Critique of Pure Reason*, Kant says, “All unification of representations demand unity of consciousness in the synthesis of them. Consequently it is the unity of consciousness that alone constitutes the relation of representations to an object” (B137). He further states, “Only the original unity of consciousness is valid objectively” (B140).

My interpretation of Kant’s self-styled “Copernican revolution” is that the object’s way of *being* is brought about by the unity of objects as the various intuitions (“the manifold of intuitions”) that are assembled and synthesized by the mind through the stratum of concepts and categories. Thus the assembler-mind is what puts an object into existence in the first place.

The above summary of Kant’s ideas is very crude, of course. The crucial takeaway for us is that, per Kant, the synthesis of an object is entirely mind-dependent. Mind gains epistemic access to the object through innumerable but, importantly, a *finite* number of perceptions and then synthesizes the input with the help of categories that could be either *a priori* or *a posteriori*.

By way of an example, let us construct a simplified practical setting. Let us say there is an apple on my desk, and its properties cohere with some set of metaphysical ontologies. We do not know anything about the nature of this coherence, we simply assume that there is some kind of mapping between the object's so-called noumenal essence and its perceived existence. My epistemic access is reduced to a number of intuitions (concepts) about this apple, say, its color, size, texture, etc. There is much to be said about why distinctly different individual minds would have the identical conceptual intuitions about this object, but let us assume for the sake of the argument that all of the individual minds are endowed with the exact same *a priori* category *grid* regarding the apple. Essentially, we assume that all humans share the same cognitive structure and that our experiences are consistent from one time to the next, from one individual to the next. Far from being a foregone conclusion in light of present-day science, this was a consensus view in Kant's time. As such, the apple would be perceived identically by all mind-endowed observers; i.e., all observers would perceive it to have the same spatio-temporal representation: it is an apple two inches in diameter and is sitting on my desk at 2:00 p.m., it is green, has a temperature of 72 degrees F, has smooth skin and a myriad but finite number of other properties.

Crucially, the very fact of this apple *being*—its property of existing, its unity as an object assembled from the various qualities it possesses—is, according to Kant, a function of an individual consciousness, a mind. This statement is different from the claim as to whether the apple exists *outside of me* or *inside of me*. It does not contradict Kant's refutation of idealism included in his second *Critique*. My reading of Kant on this issue is that the object *assembly*, so to speak—its phenomenology as an object—is mind-dependent. There is no consensus view or coherent presentation on what the object's noumenal states could be because, by definition, we have no epistemic access to them.

The fact that the properties are finite in number is important. A mind would not be able to ever define an object by assembling its unity if the number of properties were infinite. But if my reading of Kant is correct, the mind is specifically capable of doing just that—making objects for what they are to us. If this is so, the number of properties must be finite.

I do not know of any other way to read this if we follow Kant's logic rigidly other than to assume that the object's ontologies, whatever they may be, staying unbeknownst to our senses, are *also* brought together by our mind and our mind alone. The logic is as follows:

- An object (an apple) exists outside of our mind in some ontologically meaningful state. (Here is a scientific aside: There are various modern ways to represent ontologies. Let us take some of the more obvious ones: position and momentum of elementary particles complemented (in one interpretation) by their respective quantum mechanical wave functions guiding them, or a *Hamiltonian* equation of motion that represents kinetic and potential energy, or both. None of these is *directly* perceived by our senses, and it takes the full sophistication and might of modern equipment to prepare a single particle in a particular state. The physical states of any system—or the entire universe—can theoretically be represented mathematically by using the notions I just listed.)
- The object's phenomena (some interaction between this *Hamiltonian* and our perception) stir our senses such that we get a coherent, possibly spatio-temporally cogent representation of this object.
- Whatever it is that stirred our senses and in so doing represented phenomena to us has some kind of correspondence to the object's ontology, i.e., its noumenal state.
- We do not know what this link or mapping is, and we can happily ignore this because:

- the energy defining the ontological state (let us continue to use the Hamiltonian representation for the sake of the argument) may be scattered all over the universe but is nevertheless brought to bear in the form of an object having spatio-temporal propinquity *by our senses*; and
- we seem to be able to *define* the system *completely* by our senses on the basis of what we perceive. And by *our senses*, I assume, of course, that we could use all available instruments that we have ever invented and could, as a matter of theoretical possibility, invent and construct in the future.

In other words, if we use the formulation endowing the senses with the power to learn all there is to know about the object and utilize our epistemic access entirely, at some point of sensory perfection there should be nothing more to say about the system in question and nothing left to perceive in order to predict the system evolution forever.

So, then, is there no problem? Here is the punch line—this assertion would be less contentious if we did not have to make the following logical step: the inevitable consequence of Kant's view is that if all minds ceased to exist, the apple would not exist as such, on my desk or anywhere else, *as apple*. The Hamiltonian representing the energy situation for the system may continue to be exactly the same but there would be no apple per se. Put more formally, in order for Kant's system to work, the cognitive state of the object, is necessarily a function of the knower. The ontological essence (*noumenal* state) of the object is left a moot point but we will allow ourselves to be less concerned with this for the time being.

3. Hegel's Notion and Views on Nature

Enter Hegel. Notoriously difficult to read and interpret due in equal measure to the exceptional originality of his ideas and the bombastic style of his prose, Hegel is generally considered to be a philosopher of the par excellence. Hegel’s framework is often viewed as a backlash to fundamentally atomistic Newtonian science and the contemporaneous views of Locke, Hume, and, later, Kant, whose epistemologies presented nature as fundamentally disparate phenomena with the object unity being assembled through the functioning of the mind, as discussed in the previous section. Hegel viewed his mission as that of returning to the holistic wisdom of the Greek foundational philosophers, Aristotle in particular.

Hegel’s earlier treatise *The Phenomenology of Spirit* deals with conceptual approaches to consciousness and matter. It portrays the evolution of the Spirit, the Geist, as it moves through a succession of different stages of self-awareness. Hegel goes into a detailed discussion of sensory, experiential (perceptional), intellectual, self-conscious, and rational stages of Geist’s progression, each stage broken into multiple sub-stages. It is not important here to go into the specifics of his presentation of these stages, which is why I am providing only a cursory mention of them. I am interested in what induces the Spirit’s dynamics to understand the force that accounts for the Spirit’s successive transitions.

Per Hegel, the motivations behind the development of the Spirit and its transition to a succession of higher states are the inner contradictions that the Spirit faces at each stage, rejecting each of the intermediate states as inadequate for its purpose of being. The dichotomy of the *singular* (or *individual*, as some translations have it) and the *universal* lies at the center of the tension. In *The Phenomenology of Spirit*, Hegel says, “This unity is at the same time affected with division, is again broken within itself, and from it there emerges once more the antithesis of the universal and the individual” (134). This tension (*dialectical unity* and *antithesis*, in Hegel’s language) is explored at each and every stage from different conceptual angles. At each stage, the consciousness is left unhappy with how the contradiction between these opposing notions is resolved, prompting it to seek answers at higher levels of the Spirit's evolution. At its pinnacle, the Spirit attains the ultimate knowledge of itself, absolute knowledge.

Even though interpretations vary, there is not much disagreement among Hegel scholars on the main point of his advocacy for the universal and the inadequacy of the individual to account for what it means to *be*. The fanciful story of Geist's transitions in the philosophy of Spirit motivated by inner contradictions at each stage until absolute knowledge obtains is a way of formulating the assertion that there is no identity other than universal identity. At a minimum, objects in and by themselves are incomplete; they need associations to be what they are.

Hegel's later text *Logic*, the first book of his *Encyclopaedia* trilogy, deals with the doctrines of Being, Essence, and the Concept. His presentation is wordy, often discursive, lending itself to multiple interpretations. To stay pithy, I will pluck what is relevant with some disregard for Hegel's context, trying to be as consistent with Hegel's semantic attributions as possible.

I am interested in how Hegel defines the notions of *universal* (*das Allgemeine*), *particular* (*das Besondere*), and *singular* (*das Einzelne*), which together form the Concept. Hegel provides an elaborate discussion of their relationships and lays out the syllogistic structure of the intellectual inquiry.

By way of a crude example, an object—any object—is defined by all three notions in the following way: Everything that exists is *universal*. To say that something *is* is to attribute a *universal* property to it. Philosophical literature is flooded with interpretations of what *universal* means, but one of the more coherent clarifications in my view was provided by Hegel's

American interpreter Dewey, whose postulate of object *associations* can be interpreted in the place of Hegel's *universal*. In order to *be something*, an object needs to *be* in the first place. Now, is the object's *being* established first and its associations come second, or do associations define what an object *is*?

To simplify, is the table less of a table as an object if we do not associate it with dining or sitting or with any of the other exogenous functions and properties commonly characteristic of what it is like to be a table. A pile of wood assembled in the form of a table does not define the object *table* in the same sense as a pile of wood, provided all table-appropriate associations are given. The problem is that associations breed new associations until the entirety—the whole of everything that we ever have epistemic access to—is accounted for in some form.

The *particular* concept, say *clock*, includes all clocks. It is the property of the *clockness* of clock (or the *manness* of men, or the *squareness* of a square). Clocks may have an association with timekeeping (universal property), but so do watches. Clocks, however, are differentiated in that they hang on walls or sit on surfaces, whereas watches are worn on a wrist. It is a common character or nature we think of when dealing with things (such as the timekeeping property of clocks *and* the fact that they hang on walls, for example), with a complete disregard for their individual differences. Lastly, the clock in my office would be a set consisting of a single item, a *singular*.

It is easy to see that all three notions have a web of interrelationships in order for the object definition to be meaningful. Also, Hegel's holistic claim would be that it is impossible to define clocks for what they are without referencing nonclocklike objects. For example, the fact that clocks (by way of an example) are made of wood means that there are other objects made of metal, or the existence of a round dial implies that other objects may not have a dial at all or that the dial is square, and so on. Further, it would be necessary to make a utilitarian association with timekeeping in defining what it is like to be a clock. These characterizations establish clocks' particular property. In its most radical interpretation, to be a clock is *not* to be a *nonclock*. Finally, in order to be a clock, at least one clock needs to exist, having at the very minimum a position in space, thus assuring the property of singularity.

Again, Hegel's lengthy discussion amounts to the claim that the three categories cannot be defined without referencing one another, even though a human mind or human understanding can delude itself into thinking that those categories are in fact separable.

Importantly, Hegel further asserts that the very nature—the very fabric—of reality is structured in exactly the same way as these syllogistic notions. Here is nother well-seasoned example:

- All men are mortal.
- Socrates is a man.
- Therefore, Socrates is mortal.

This example relates *mortal*, a *universal*, with *man*, a *particular*, and with *Socrates*, a *singular*. The by-product of this discussion is the conclusion that everything is a Concept. Indeed, if everything can be broken down into a syllogism, with the middle term (*man*) linking the major, universal term (*mortal*) with the minor term (*Socrates*), and if all of these terms are part of a Concept, then everything *is* a Concept. Crucially for us, this means that exactly nothing can be specified without reference to the universal. Without being mortal (and other things attributable to humans), *Socrates* or a *man* would have no identity whatsoever.

4. Views on Nature

Nature, the second book in Hegel's trilogy, provides content for syllogistic structure examining physics, chemistry, biology, and other sciences. It is a matter of some interpretation, as is often the case with Hegel, but his articulated rejection of Newtonian science, his misinterpretation of the most successful theories of the time, and his profound Christian religiosity can come across to a practicing scientist as unintelligible at best and utterly senseless at worst, so much so as to prompt the foremost scientist of the time, Helmholtz, to opine:

> "His system of nature seemed, at least to natural philosophers, absolutely crazy. . . The philosophers accused the scientific men of narrowness; the scientific men retorted that the philosophers were crazy. And so it came about that men of science began to lay some stress on the banishment of all philosophical influences from their work. Thus, it must be confessed, not only were the illegitimate pretensions of the Hegelian system to subordinate to itself all other studies rejected, but no regard was paid to the rightful claims of philosophy, that is, the criticism of the sources of cognition, and the definition of the functions of the intellect. [2]"

Even allowing for the limited scientific yield available to Hegel in his time, a philosopher of science who read only *Nature* could be well justified in dismissing Hegel's relevance out of hand. Viewed from today's vantage point, a list of the specific well-articulated mistakes that Hegel made is long. Among the more obvious analytical gaffes are:

- unambiguous and vocal rejection of Newtonian mechanics;

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[2] Dampier, W.C. *A History of Science and its relations with Philosophy and Religion* (Cambridge University Press, 1971), p. 292

- fanciful views on fire, water, air, etc. as constituent, indivisible elements of nature;
- self-identity of light and the claim that light cannot be a composite ("a crudest of all metaphysical propositions" [*Nature*, §320]) of either particlelike or wavelike components;
- definition of what a color is;
- homogenous self-identity of water and the postulate of oxygen and hydrogen coming into *being* when water is broken down into them chemically or electrically, rather than pre-existing as separate chemical compounds;
- nonsensical metaphors with respect to gravity;
- opposition to "new French chemistry" that advocated the foundations of chemical processes on the basis of immutable elementary particles; and
- fanciful definitions of life.

We cannot simply disregard the details of Hegel's views because he was not a natural scientist. Hegel shows a remarkable factual knowledge of the scientific accomplishments of his day. What is patently wrong is specifically his interpretation of scientific phenomena and his obsession that the phenomena mimic the Notion. And interpretation is what the philosopher's job is.

Under the weight of overwhelming evidence of erroneous and often absurd judgments, it would appear that we should conclude that Hegel is simply wrong, that his method is at best speculative and fanciful, and that, in any event, it does not lead to what it lays claim to, i.e., accumulation of knowledge.

Taking this point of view, in other words, means that the reliance on the Notion does not bring any new scientific theories or new discoveries. We thus cannot improve our understanding or knowledge of the existing theories, and by employing Hegel's method, we would be setting ourselves up for the trail of mistakes that befell him. We would need to admit that his system is simply a mental hat trick to account for existing phenomena to make a mortal and limited mind happy with what we perceive. Superficially, the Hegelian *reason* that has Notion as its foundation cannot be the basis for the scientific project.

I argue that none of the above is correct and that Hegel's system in a broad sense is vindicated by the most modern of all fundamental theories in physics—quantum mechanics. I will present the analysis of my argument in the next section.

To have a cogent introduction of this analysis I would like to establish whether the applicability of Hegel's system should be considered with respect to present-day science in the first place. We may find that the two courses of inquiry operate in vastly different domains. For example, we would not attempt to measure time with a mechanism designed to measure an electric charge. In order to establish coherence let us see how Hegel viewed science. We will be looking for some compatibility of terminology.

Ever a controversial topic, there is no consensus now and there was certainly no agreement in Hegel's time as to what the scientific project is, so to his credit, at the beginning of *Nature*, Hegel attempts to set the boundary between science and common sense. He invokes the categories of *thought*, *abstract*, and *universal*. Science, even though based on our access to empirical phenomena, deals with the notions of *universal*, *abstrac*t, and *permanent*. In so doing, it advances thoughts into their pure form, whereas everyday commonsensical acts are for the most part of a practical nature, defining "things-in-themselves" and thus far conceptually limiting.

Michael Inwood, an Oxford scholar of Hegel, reviews the critique of Hegel for this distinction, arguing that these categories are “not fine grained enough to capture what differences there are” (Inwood 50). In Inwood’s view, it is self-evident that scientific theories provide for a higher level of abstraction in describing phenomena, if for no other reason than the fact that making *generalizations* is part and parcel of what a scientific project is. He sees the problem in that the categories invoked by Hegel, ostensibly crucial in making the difference, were available to prescientific agents, and their use by science is a matter of a degree rather than principle.

Per Inwood (and I agree), observing that both apples and, say, metal rods dropped from the same height reach the ground at the same time does not *ipso facto* make for science per se, even if one elevates the falling substance to the category of an *object*, thus abstracting the thought from the specific apple and the specific metal rod. In this example, science starts with the mathematics of the universal law of gravity. Mathematics, however, in a certain sense is a method for manipulating symbols that are nothing but abstractions decoupled from the empirical content. If, as I do, one deems mathematics a requisite element of practicing a natural science, requiring Hegelian *abstraction* for the sciences is not far off the mark.

Today’s sciences also attempt to discover laws of nature, both universal and those with a specific domain. The path to elevating something to the position of a law from that of an observable regularity is long and thorny, but that it is exactly what science’s ultimate achievement is commonly viewed to be—discovering, describing, and providing a taxonomy of universal laws. Hegel’s obsession with the Notion and his 500-page attempt to draw parallels between the syllogism of the Notion and physical phenomena aims at just this—establishing a universal law of nature.

The agreement between Hegel's view of what science is and today's definition is somewhat illuminating but is certainly not sufficient to lend Hegel any credibility as a philosopher of science. If we are to invoke Hegel today as a reference in any meaningful sense, we would need to provide the basis from which his approach is to be invoked. As I mentioned above, the task at hand is obscured by his views on *specific* scientific issues having no more than a historical significance. I argue that the specific mistakes that Hegel made in the context of what scientific data were available to him at the time are not important. Our intellectual inquiry should focus on whether his approach would benefit the interpretation of scientific phenomena.

Let us remember that the overarching postulate in *Nature* is this: nature, motivated *Notionlike* by its inner contradictions, moves from the state of "asunderness" (defined *singulars*) of its mechanical stage toward relational processes of its chemical stage that bring "unified neutrality" to hitherto opposed objects and further toward a biological and organic stage where the *emergent properties* take over the definition of what the object is. The *property of transparency* of a piece of glass is what is important for it to be a piece of glass, not just the fact that it is made of silicon. Or, in a cruder example, table is what we have dinners and meetings at, not the fact that it is made of wood or other material. The fact that clocks tell time is what makes them clocks, not the fact that there is a wound-up spring in the middle that moves their hands.

At its core, Hegel's case often rests on pointing out emergent properties of substances and their irreducibility into component parts. This is not a preposterous idea. There is an illustrious history of this discussion advocated by a school of British emergenists—J. S. Mill, C. D. Broad, and S. Alexander—who have been arguing for a century on the issues of the foundations of emergent properties, the topical issue being the irreducibility of mind and cognition to brain functions. The central idea is that matter's increasing complexity leads to properties that are a result of the *interaction* of components rather than the definition of the state of the components themselves, but these interactions do not supplement or supersede the fundamental interactions.

The emergenist theories ring close to what Hegel advocates in my view, but at this point, there is only a cursory resemblance. Indeed, can the emergent properties be completely defined by specifying the states of their constituents? Or are they truly something new? Are there new causal relations that emerge that cannot be accounted for by the constituents?

The most important part of this investigation would be to establish whether Notion could be redefined in light of what is afforded to us by modern science. I would need to prove that Hegel's general application of the syllogistic concepts of the Notion, the claim that these concepts define each other and that one of these concepts cannot exist without the others, has a close relationship with scientific phenomena as we understand them today. This is a big claim.
I will advocate in the next section the view that a holistic approach may have far deeper scientific backing at the level of fundamental properties of elementary particles. In that sense, Hegel's system, which otherwise should be branded purely speculative in its applicability to natural sciences, may receive a new level of philosophical relevance. There are numerous ways to draw parallels in such cases, and the connections are often nothing more than vague metaphors. We need to ensure that the truth value of the new definitions and those of the traditional Hegelian terms correspond in a meaningful way.

In the meantime, the summary of this chapter reduces to the following two posits:

1. Hegel's system advocates holism in the most rigid sense; it advocates this approach to nature through self-proclaimed opposition to the atomistic, reductionist views of Kant, Hume, and Locke. In today's language, for him, the system is never completely defined until the

entirety of the universe is specified. My reading of Hegel's "Absolute Idea" that Geist attains at the end of its journey amounts to nothing less than the physical specifications of the universal whole.

2. A by-product of Hegel's system is a realist view of the ontologies. In the *Logic*, Hegel rejects the atomistic approach to nature and advocates the *ontological primacy of the object*; individual mind does not have any role in making objects what they are. It is this conclusion of Hegel's that I advocate is relevant to the present-day philosophical realism feeding the conceptual foundations of modern science.

5. Modern Arguments from Physics

I claim that the concepts of *individual*, *particular*, and *universal* could be redefined as physical systems that happen to be in particular states. Quantum mechanics, an astonishingly successful physical theory unrivaled for its precision and prediction power, will be the setting for our discussion.

Let me order my definitions first.

I will understand *system* as anything that has a phenomenological attribution (something that we can effect a measurement upon and perceive the resultant property of) that we wish to consider *in itself*. *In-itselfness* means that the system needs to be defined completely separately from anything else; no interactions with the outside world are allowed. An individual physical system could be anything—say, a book on my desk.

We will also need to specify the state of the physical system that we choose. A *state* is a physical situation of the system. We can specify a state for the book on my desk by saying that it is title page up or title page down, or that it is *x* inches from the edge of the desk, or that a certain amount of light shines on it, etc. This latter specification, however, would mandate the inclusion of light and its source into the system as well. That is not a problem conceptually, but it would be a significant and unnecessary practical complication. In order to completely and precisely define the state of this book, we would need to come up with conditions in which the book and whatever else we include in our system do not interact with other objects—not with the air surrounding it, not with specks of dust, not even with light (and by light I mean a single photon)—because any such interaction could potentially change the state of this book and in so doing violate what we mean by a system (remember, a system is considered in itself).

Clearly, it would be nearly impossible to prepare such an ideal setting for a book on my desk, so I suggest that we purify the argument and denote a single elementary particle in a vacuum as an individual physical system, say, an electron in state X. This state could be further broken down into the electron's position, momentum, and spin. The very fact that we are talking about an electron and not another particle already defines the mass and the charge, and its position and momentum are accounted for in the so-called wave function.

A wave function needs an introduction to a nonspecialist. It is essentially a complex mathematical statement and can be viewed in a number of different ways. There is an agreement among physicists that, at a minimum, a wave function is (1) a computational convenience used to establish particular probabilities of the system's measurement, and (2) a statement that the system (an electron particle in our example) exists. The existence is asserted by the so-called normalization of the function, i.e., a procedure that adjusts the mathematics such that the cumulative probabilities[3] of particle location are equal to unity.

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[3] By probabilities, I mean the ratio of the occurrence of a measurement of an identical system in the limit of infinite number of measurements.

A very useful feature of the wave function is that, being in essence a solution to the differential equation of motion describing all there is to know about the elementary particle in question, it can be expressed in terms of different properties of the system with precise mathematical equivalency. It is simply a matter of preference regarding the property for which we would like to predict the measurement.

A third view of the wave function that I support has been advocated relatively recently. It claims that the wave function has an independent ontology, similar to that of the electromagnetic field.

Another important property of a quantum system is referred to as the *spin* of an elementary particle. A spin is the property that generates a magnetic moment of the particle without reference to its spatial motion; it is intrinsic to the particle. Physicists refer to it as another *degree of freedom*, i.e., a property without which the specification of the state of the particle would not be complete.

All of the above refers to an *individual* system. Indeed, the system that I chose—a specific electron that has the location in space and a defined momentum, spin, and other measurable properties—is nothing but a thing-in-itself, per Hegelian terminology.

A *particular* can be viewed as a set of physical systems, a set of individual sets consisting of one electron each. The commonality between them is that they are all electrons, meaning that they have a precisely identical mass and energy charge. They may be in different locations, but they are all electrons. Semantically, my suggested individual electron set would be very close to a set *Socrates*. A set of individual electron sets is paralleled with a set *human* whereby the *human* set, including the *Socrates* set and a *Plato* set, is similar to an *all electrons* set, including all individual *electron* sets. In this example, the spatial position of the electron in each set would be different, just as the names of Socrates and Plato are different.

A universal collection of all physical systems—i.e., the state of the entire universe defined precisely—is a *universal* set. In the syllogism example, with "Socrates being human being mortal," *mortal* was the universal property, and it defined what it was like to be a human. Of course, the implication was that to define what *mortal* means, one would need to invoke other terms such as *life* and *end*, and to define those would require yet other terms and so on until the entirety of the universe was defined. In the example of an elementary particle, the argument can be sharpened by simply saying that *universal* means everything there is to know about the entire universe, i.e., its state.

The question now becomes exactly how we define the *state* of the individual electron set, the *individual* system, as I called it. This is the central focus of our discussion, as announced, and this is exactly where the problem starts. The views on what defines the state of an elementary particle in quantum mechanics diverge in technicalities, but the nuances of that discussion will not change the shape of my argument.

In simplest terms, defining the state of a physical system involves expressing its precise position in space as well as its kinetic and potential energy. Kinetic energy, momentum, and velocity can be viewed interchangeably, as they are all functions of one another if the mass is set. The particle in our case is not interacting with anything else, so the potential energy of the system is zero. In fact, any other property of any physical system whatsoever would be a function of the position of its elementary particles and their velocities, except for spin.

For our purposes, the wave function plus a spin (or a spruced-up version of the wave function that takes account of the spin) is *all* one needs to know about the physical system called *electron in a vacuum* to predict all measurements and the motion of this system, i.e., all possible epistemically accessible properties of this system right now and for a billion years to come.

In our everyday language and experience, *defined* is an attribution of the precise mathematical quantity of the property in question. For example, to say that I am looking at either Socrates or Plato with a fifty percent probability of the human I am looking at being one or the other would lack definition. We would need to make an attribution of *Socrates* with a probability of unity for the definition of the state of the system to be accepted; otherwise, the system would be *undefined*, so to speak. My interpretation is that, common experience aside, this is the only way Hegel would agree to Notion's concepts being defined.

With this approach, a whole slew of problems with our electron immediately presents itself.

First of all, the state of an electron cannot be defined classically. What physicists refer to as classical definition requires a definite, mathematically precise position and the velocity of an object, as just discussed. In our everyday perceptions, things have definite locations—chair at such-and-such a distance from the door, a kitchen spatula in such-and-such drawer, etc.

Quantum scales, approximately $10^{(-35)}$ of a meter, afford no such luxury. Also, things change between thinking of a quantum system and trying to acquire epistemic access to it. This change is often referred to as the act of *measurement*.

Let us talk about what *measurement* in the general sense means. From a practical standpoint, it is an act of acquiring epistemic access. Conceptually, it is a way of establishing a physical record of something. The act of measurement necessarily involves some measuring apparatus that, in order to effect such a measurement, necessarily needs to interact with what is being measured. For simplicity's sake, let us just say that in order to see something, one needs to bounce at least one photon off it. In order to establish the energy level, one may need to bounce a charged particle off an object, and so on. There is no such thing as a perfectly passive measurement. However small, the system under measurement will always experience some disturbance.

In our chosen system (electron in a vacuum with no fields interacting with it) prior to measurement, the electron's location is not and cannot be defined. There is *no fact of nature* about its precise location. There is a wave function, as described above, that makes a *prediction of the probability* of its location across the entire universe. The function expressed in terms of position is peaked in certain areas, meaning that there is a higher probability of the electron being in those areas, but—and this is important—the particular electron that I am trying to determine the location of and that appears to be right in front of me and is part and parcel of the physical system that I set up has a nonzero probability of being at Alpha Centauri prior to my measuring it. The fact that I am not capable of ascertaining its location with precision is not a question of my measuring apparatus being imperfect. The entire point is that there is no matter of fact about its position *prior to measurement*, just as there is no matter of fact about the political affiliation of a doorknob.

If what I say is correct, and the theory of quantum mechanics says it is, the system of a single electron prior to measurement is not defined, as established earlier, meaningfully (precise position and momentum)—that is, until something disturbs it. A disturbance is nothing but an interaction with another system (a measurement apparatus in our example). Therefore, an *individual* set is never defined completely and precisely *by itself* at the point *prior* to acquiring epistemic access to it.

Let us disturb our system by enacting the position measurement. It is no small technical feat, but it is theoretically and practically achievable. The astonishing effect is that at the time of such a measurement, the other essential characteristic of the system—the electron's momentum—becomes undefined. Again, there will be no matter of fact about the electron's precise momentum. And likewise, if we measure the momentum precisely, the position becomes undefined contemporaneously with the measurement of the momentum property. The technical term for the above is *noncommutability* of the position and momentum operators.

The quantum mechanics formalism specifically prohibits the simultaneous definite states of the position and the momentum of the system in and by itself, metaphysically or phenomenologically. So the only *state* definition possible for the electron would be along the lines of "this electron is a little bit here, a little bit there, and a little bit everywhere," and the same for the momentum. This, of course, would invalidate the posit about zero potential energy, i.e., the interaction potential of the particle with other fields that I equated to zero in order to consider the system *in itself*. Indeed, since the electron is dispersed with nonzero probability across the universe, there is a certainty of it interacting with other particles or fields somewhere. Importantly, even if the entire universe consisted of just one electron and nothing else, the statement would still hold true.

Things get murkier when we try to define another essential property of an electron, without which the description of its state would be incomplete and which is not a function of any other property. That property is *spin*.

An electron's spin is measured cumulatively by a number 1/2. It also has values along the *x*-, *y*-, and *z*-axes, where it can assume an *up* state or a *down* state. Similar to what happens when trying to determine the particle's exact position prior to the measurement, the spin along, say, the *x*-axis can be fifty percent probability up and fifty percent probability down. This counterintuitive state is often referred to as *superposition*. Once measured, the spin assumes a definite property along the axis on which we measured it but necessarily becomes undefined along the other axes.

And here is the pinnacle of the indeterminacy: pinpointing what the spin is gets markedly more difficult as electrons can get *entangled* with other electrons. *Entanglement* is a technical term that means that particles interact at any distance *instantly* based on the history of their prior interactions. They appear to have a prior agreement, for lack of a better word. They do so by assuming certain spin values that are perfectly synchronized with one another. Simplistically, if both particles had a superposition of their *x*-spin prior to the measurement and *then* one of the particles is measured to be in the *x*-spin-up state, the other necessarily will be in the *x*-spin-down state at the moment when the first particle gets measured. And particle one can stay in the *x*-spin-up state only for as long as the other particle is in the *x*-spin-down state.

The technical discussion of entanglement has its iconic interpretation in the work of John Bell, who famously showed that QM is incompatible with our everyday understanding of the world. And by everyday understanding, I mean our classical propensity to itemize (atomize) our perceptions by way of precise and complete definitions.

It is a theoretical impossibility to define the spin state of one particle without accounting for the other. The individual system of one electron can thus never be defined completely and precisely in and by itself. Bell's theorem is often called the "local hidden variables" theorem and can be viewed as a claim that the world, as predicted by quantum mechanics, cannot be defined locally.

What I am describing involves reference to quantum mechanical formalism, so an uninitiated reader may feel compelled to be skeptical about it on account of quantum mechanics being just another scientific theory, with most theories tending to be proven wrong over time. Also, its name is often brought up by laymen in a number of pseudoscientific endeavors, the most absurd and comical examples I have ever come across being quantum healing and quantum gardening. For the skeptic, it is important to note that what I am referring to is the precise mathematically formalized theory, no postulate or prediction of which has ever been proven false by a century of trying, so it is exactly where our present-day science is and is the basis of roughly 40 percent of all technology that humanity uses at the moment.

Conclusions

The view, supported by Hume and Kant, on how our mind acquires epistemic access and presents the world as we know it by assembling little chunks of perception over the grid of categories is thus invalidated by the physical impossibility of defining things with precision separately. This physical impossibility is the universal law of nature. If the arguments I present are valid, they can be nothing less than a vindication of the crux of Hegel's *theory of the whole*, his mistaken views on the physics of his day notwithstanding.

To summarize:

- Objects exist independently of the mind;
- They are irreducible to parts;
- An object or a system could never be *completely* specified without specifying the entirety of the universe.

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