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QUANTUM MECHANICS:

A DIALECTICAL APPROACH TO REALITY

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In a recent article, Wolfgang Smith states that "the ongoing de-Christianization of Western society is due in large measure to the imposition of the prevailing scientistic world view."(1) One need be neither a philosopher nor a scientist to notice that de-Christianization makes its presence felt in every aspect of the life of a citizen in the modern West--familial, professional, cultural, and religious. Thus it opposes the two-and-a-half-millennial tradition that began in ancient Greece and achieved its full development in medieval Christian philosophy. This tradition is one of constant refinement and crystallization, continuously coupled with and catalyzed by the divine plan of salvation of mankind from the bondage of original sin. This complex phenomenon was well encapsulated by Etienne Gilson:

> It is hardly possible to realize the continuity that prevails through the whole history of Western culture, unless one keeps in mind the important part played by the Church in the work of its transmission. The Greek and Latin Fathers of the Church had so carefully preserved the classical notion of man that when St. Thomas Aquinas, in the thirteenth century, undertook to build up a complete exposition of Christian truth, he did not scruple to borrow for his technical equipment from the pagan Aristotle, whose logic, physics, biology, ethics and

> metaphysics were then transformed by his medieval disciple into as many elements of Christian synthesis.[(2)]

This Christian synthesis is central to the understanding of science as an integral part of the classical Western world view. In it all beings are perceived as purposefully ordered in their natures towards their ultimate goal, which is the glory and praise of God. In his *Summa Theologiae* St. Thomas writes

> Therefore since sacred scripture considers things insofar as they are divinely revealed, according to what has been said all things whatsoever that are able to be divinely revealed share in the one formal object of this science, and so they are included under sacred theology as under a single science.[(3)]

This position radically contradicts the currently dominant mind set that goes back at least to Descartes's decoupling of philosophical and theological wisdom, with its bifurcation of nature into *res cogitans* and *res extensa*.[(4)] As the term *extensa* indicates, in Cartesian philosophy matter appears to the human mind clearly and distinctly only under the aspect of quantity. All the other Aristotelian categories of accident are thus reducible to quantity. As a result the human mind is unable to discern natures, and so is cut off from the possibility of investigating change, the object of physical science.[(5)] The Cartesian assimilation of corporeality to pure mathematics, based on Descartes's own distrust of sense experience, has boxed science into, one could say, living a life of extension without any reference to the nature of reality. The mathematicism of Galileo, and in some ways that

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of Isaac Newton, further implanted a conviction in the modern mind that physical phenomena can be accounted for simply by the use of mathematical equations. The implications of such reductionism were well summarized by Alfred North Whitehead:

> The laws of nature are nothing else that the observed identities of pattern persisting throughout the series of comparative observations. Thus a law of nature says something about things observed and nothing more. The pre-occupation of science is then to search for simple statements which in their joint

> effect will express everything of interest concerning the observed recurrences. This is the whole tale of science, *that* and nothing more.[(6)]

Prior to Descartes, however, science breathed a different air, as evident in the works of St. Albert the Great:

> Mathematical abstraction, for Albert, necessarily eliminated from consideration the four types of natural causation; what it retains is a shadow reflecting something of the formal cause. The shadow, or quantitative image, such as figure, measure, number and velocity, which is utilized in a mathematical approach is therefore not an "explanation" why events take place, but measured data which can be accounted for in terms of geometrical figures and determined proportions.[(7)]

St. Thomas Aquinas compared the contribution of mathematics to natural science with the use of metaphysics in a legal case, or poetry in theology, stating that the explanation of natural phenomena through mathematical principles is an explanation through a "remote cause."[(8)]

In his *The Quantum Enigma: Finding the Hidden Key*, Wolfgang Smith has undertaken a valuable and long-awaited effort of revitalizing the traditional picture of reality by reuniting the quantitative properties of things with their corporeal natures.[(9)] According to Smith's suggestive nomenclature, every "corporeal

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object" is associated with a "physical object" from which it derives all of its quantitative attributes. This accords to a remarkable degree with St. Thomas Aquinas in his commentary on Boethius's *De Trinitate,* where he identifies a physical object with the intelligible matter that is the proper object of mathematical analysis.[(10)] With this as a background, it is not difficult to understand why reductionist Cartesian epistemology focused on intelligible matter alone, leaving the corporeality of sensible matter blurred and indistinct.

The purpose of this paper is neither to demonstrate the metaphysical adequacy of quantum mechanics nor to reject it as the wishful thinking of mathematical formalists. Quantum giants such as Planck, Schrödinger, and de Broglie were truly brilliant, and the results of their labors have been well confirmed by experiment. No one to this day, however, has seen a wave function or a molecular orbital. Whether someone will in the future is too uncertain for speculation. What can be done now is to offer a hypothetical assessment of the epistemological worth of quantum mechanics, so that when a scientist starts "peeling off" the orbitals from a molecule of sucrose with micro-tweezers even philosophers can sit back and enjoy their afternoon tea. The tools of this task seem to be at hand. In particular, the alternative interpretation of quantum mechanics proposed by David Bohm could help quantum physicists to recognize the four fundamental Aristotelian causes and to demonstrate the validity of their discipline as a Thomistic *scientia media*. Ultimately it may then be possible to harvest the insights of this and other recent physical theories within a coherent philosophical framework rooted in the Christian tradition of the West.

I. Corporeality Kills the Cat

The importance and uniqueness of Smith's approach to quantum mechanics warrants our reverting to some fundamental conclusions of his *The Quantum Enigma* that relate to the

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problem of measurement. In particular, looking at his proposed mechanism of measurement will help us to sort out certain metaphysical quandaries that inevitably result when quantum mechanics is interpreted solely in terms of probabilities.

To observe any physical process, Smith argues, one must use an appropriate measuring device, be it a ruler or a spectrometer, so that the measurement always terminates in a corporeal entity. Accordingly, the measurement entails the actualization of a numerical value that resides potentially in a physical object, otherwise known as intelligible matter.[(11)] Thus the measurement may be understood as a "transition from the physical to the corporeal domain." Such a transition cannot be explained by classical post-Cartesian mathematical physics, for the simple reason that this physics does not acknowledge the existence of any corporeal reality that is capable of actualizing a measurement. To remedy this, Smith offers his own interpretation of quantum mechanics.

In quantum theory one considers a single particle that can simultaneously occupy two independent states, A and B, described by wave functions y_A and y_B respectively. The resulting combined state of such a particle is expressed by a linear combination of the two wave functions with appropriate coefficients:

$$Y = c_A y_A + c_B y_B$$

According to the commonly accepted Copenhagen interpretation, these coefficients stand for the probability of finding the particle in state A or state B.

The obvious difficulty is that while the above equation postulates the possibility of a concomitant presence of the particle in both states, the act of measurement always yields a single value. In other words, something that initially exists as composite undergoes a transformation to a noncomplex entity.

Smith understands this to be possible because of the transition from a physical object to a corporeal object. One may grant that the problem posed by quantum theory is ontological as well as

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physical, but one wonders how Thomistic the ontology may be. When opposing a "physical object" to a "corporeal object," one instantly feels an uneasiness with Smith's bifurcating a single being into separate objects or separate ontologies. Metaphorically, Smith's physical object can be likened to a subsistent multidimensional matrix of all possible quanta associated with each existent, permeating it in some quasi-mystical way. In reality, however, the physical and corporeal "objects" are but composites of the single being signified by the Thomistic dictum *materia signata quantitate*. Therefore, Smith's proposal of a double ontology does not eliminate Cartesian bifurcation, although the inaccessibility of the corporeal nature imposed by Descartes no longer constitutes a major epistemological obstacle.

The key explanation of the "metaphysics" of measurement, however, relies solely on the theoretical process of quantum state vector collapse which Smith illustrates with the paradox of Schrödinger's cat:

> The disintegration of a radioactive nucleus triggers the execution of the now-famous cat. According to quantum theory, the unobserved nucleus is in a superposition state, which is to say that its state vector is a linear combination of state vectors corresponding to the disintegrated and undisintegrated states [see above equation: states A and B respectively]. The superposition, moreover, is transmitted by virtue of the experimental set-up to the cat which is consequently in a corresponding superposition state, i.e., dead or alive. It remains, however, in this curious condition until an act of observation collapses its state vector and reduces it to one or the other classical states [either A or B].[(12)]

Smith concludes that

> What is special about the measurement is the fact that it realizes an ontological transition from the physical to the corporeal domain. . . . Schrödinger evolution operates within the physical domain whereas projection has to do with a transit out of the physical and into the corporeal.[(13)]

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In light of St. Thomas's position on the relation between the mathematical and natural orders and the corresponding modes of scientific demonstration, one might here raise an objection that goes to the very foundations of quantum mechanics. This theory is derived *a priori* from mathematical speculation.[(14)] Mathematics, devoid of any immediate relation to sensible matter, is operative only in the domain of quantity, whereas physical science studies the natures of really existing bodies in which sensible matter is a primary component. From a Thomistic point of view, however, Smith's transition from the physical or quantum mechanical order to the corporeal, seen as a result of the collapse of the quantum state vector during the process of measurement, appears to be problematical. Consider, for example, the measurement of temperature or weight. It is obvious that such a measurement involves an action of an object being measured on a measuring device. Thus thermal energy is transferred to a thermometer, or gravitational energy is passed onto a scale, to obtain the respective temperature or the weight of a body. The process of measurement therefore involves accidents on both sides of the experiment, with the action of a measured object and the passion of an analytical instrument forming a single motion. It is clear that a transition from a mathematical domain of a priori, postulated, accident-less, intelligible matter in quantum mechanics to the sensible domain of a measuring device lacks the necessary elements to constitute a motion in the Thomistic sense.

Addressing the issue of motion and measurement in his commentary on Boethius's *De Trinitate,* St. Thomas Aquinas states that:

> It does not belong to the mathematician to treat of motion. Therefore inasmuch as the principles of quantity are applied to motion, the natural scientist treats of the division and continuity of motion. And the measurements

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of motions are studied in the intermediate sciences [*scientiae mediae*] between mathematics and natural sciences: for instance in the science of the moved sphere and in astronomy.(15)

Unfortunately, the speculative and dialectical approach of quantum mechanics precludes it from achieving the status of a *scientia media*. As St. Thomas states: "in the mode of consideration [of *scientiae mediae*] that which is physical is, as it were, material, whereas that which is mathematical is, as it were, formal."(16) In the Copenhagen interpretation of quantum mechanics, the material on which it focuses are abstract functions and probabilities. Thus the use of quantum theory to explain the mechanism of measurement on sensible objects seems, strictly speaking, to be impossible.

II. Bohm Plays Classical

While the classical physicist may feel comfortable in characterizing the macroscopic world, he has always been restrained in attributing full reality to molecules, atoms, and elementary particles. It is indeed too difficult to investigate singly the great number of particles that an appreciable quantity of gas contains (22.3 liters of gas contains 6.02×10^{23} particles). The inability to discern every individual entity in such an ensemble has thus pushed physicists to resort to statistical methods that retrieve at least some information through the computation of average values for the entire ensemble. This amounts to an acknowledgment of the weakness of scientific method in the microscopic world.

The indeterminacy such a method involves is not thereby inscribed into the nature of an individual particle. Yet quantum mechanics as presented by the Copenhagenists seems purposely to penetrate into the single particle realm by imposing on it Heisenberg's uncertainty principle. According to this principle one cannot at the same time determine precisely the velocity and

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the position of an elementary particle. When velocity is known accurately the position is indeterminate, and vice versa. Nature, however, is governed by laws that express its tendency toward a fixed end under a given set of conditions, indicating that finality is the ultimate reason for determinism in its motions. By negating any fundamental law governing the velocity or position of a particle, one denies the innermost reality that sets it on the way to a particular end, thereby negating the particle's finality. That was the position held by Heisenberg when he advocated indeterminism as an inherent property of matter. He was contradicted by later quantum physicists such as Einstein, Schrödinger, and de Broglie, who shifted indeterminism into the subjective realm by associating it with a radical incompatibility between the observer and the thing observed.(17)

Regardless of this diversity of opinion, quantum mechanics as a theory in itself remained insensitive to finality. The commonly accepted interpretation of quantum mechanics is based on a stochastic model in which a particle is described by a wave function that gives the probability of its being found in a certain area of space. For almost a century now, this probability function has been used to foster the belief that chance and chaos reign supreme in the universe. Fortunately, however, an alternative interpretation was formulated by David Bohm in 1951. This view has been suppressed and virtually eliminated from the scientific world. Only recently have a few voices begun to explore its profound consequences.[(18)] The major difference of this view from the Copenhagen approach is the restoration of determinism at the molecular level. This shifts the indeterminism of the Heisenberg principle from the ontological to the epistemic realm, exactly where it had been located in classical mechanics.

In other words, one can describe Bohm's theory as a classical version of quantum mechanics. Particles assume precisely defined

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loci in space and are no longer delocalized. Wave functions are no longer enigmatic expressions of probabilities, but are treated like really existing force fields that determine the trajectories of particles and thus exercise efficient causality. As formal solutions of the Schrödinger equation, the laws governing the time dependence of these functions are fully deterministic. Based on the total world's wave function and particle distribution at a given time, one should thus be able to predict, with certainty, the wave function and particle distribution at any later time. Any resulting error will occur not because of an inherent determinism in the laws of particle motion, but because of imperfections in the computational method. Clearly, then, Bohm's interpretation of quantum mechanics offers a deterministic alternative to the Copenhagen approach.

When one analyzes Bohm's interpretation more carefully, it becomes clear that in these conditions quantum mechanics functions as a *scientia media.* According to the explanation provided above, force fields are material-physical *suppositiones,* while the theoretically derived geometrical contours of the solutions of Schrödinger's equation are the mathematical-formal representations of those fields. This implies that by using strictly mathematical procedures quantum mechanics is capable of providing *propter quid* demonstrations of phenomena occurring in nature. St. Thomas himself defends this procedure at the beginning of his commentary on Aristotle's *De caelo*.[(19)] William Wallace comments on this passage as follows:

> A mathematical physics--to use the modern term--was for [St. Thomas] a very real possibility, even if he had but the most rudimentary knowledge of how

> it could one day achieve the results we now associate with it.[20]

Today we place great confidence in quantum mechanics. Unfortunately we can only speculate on the correctness of this theory as more and more experimental evidence is accumulated

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in its favor. Nevertheless, Bohm's interpretation supports its proper mode of demonstration as outlined by St. Thomas. This throws new light on the results the theory has already achieved, such as the theory of chemical reactions.

III. Quantum Alchemy

The interior structure, as well as the resultant physical properties of inanimate substance, are determined by four elementary forces: electromagnetic force (chemical reactions), gravitational force (mechanical phenomena), the weak force (radioactive emission), and the strong force (nuclear reactions). No doubt these powers contribute to our understanding of the substantial forms of the inanimate world. To satisfy the Aristotelian hylomorphic theory, however, such a form must also explain why an individual substance is unified within itself and so pertains to a natural kind or species. Wallace observes that "the effect that is sought is to have the form appear as a type of field, coextensive with the substance of which it is the form and energizing the powers that are characteristic of it."[21] Clearly, the form then represents the fundamental unifying principle of a naturally existing object that determines its species, and also encompasses the aforementioned four basic powers.

Chemical reactions that occur as the result of electromagnetic interactions offer a telling example of how a substantial change actualizes a new form with radically distinct physical properties. Thus Wallace describes the formation of sodium chloride in the following way:

> When sodium combines with chlorine to generate sodium chloride, the natural form of sodium, which informs and structures the prime matter in that element, interacts with the natural form of chlorine, which in turn structures and informs the prime matter in chlorine. . . . A new substantial unity has been achieved, with radically different properties, although something of the previous substances remains in the

> substrate (PM, prime matter)--present
> as

> before and still providing the ontological ground for all
> the conservation principles that are recognized as
> such in recent science.[22]

This scenario closely portrays how the formation of chemical compounds is understood in quantum mechanics. In the simplest case of two atoms forming a molecule, the atomic orbitals of the two atoms interact with each other and by mutual overlap form a combined molecular orbital that is entirely unlike the two initial orbitals. Whether or not this resemblance corresponds to a real connection of a form and a quantum orbital hinges precisely on what interpretation of quantum theory one takes. In the Copenhagen approach, based on probabilites, it is difficult to see how atomic orbitals in nature provide the basis for *propter quid* demonstrations of molecular properties. It appears that the probabilistic interpretation of quantum theory never leaves the realm of dialectics and thus is incapable of providing a demonstrative account of natural phenomena. Within Bohm's framework, on the other hand, atomic and molecular orbitals are placed directly in nature, representing there the fundamental forces that account for the physical properties of substances and their mutual interactions. Quantum mechanics then regains its demonstrative power as a *scientia media,* situated as it is in a stable, deterministic environment of wave functions, freed from the probabilistic limitations imposed by Niels Bohr and the Copenhagen school. In such conditions, the Schrödinger equation likewise escapes from the contradiction between its inherent determinism and the stochastic character of wave functions understood as hypothetical probabilistic densities.

IV. Mathematical Metaphysics

David Bohm is noted not only for his novel interpretation of quantum mechanics but also, if not mostly, for his theory of implicate orders and undivided wholeness. He devoted a number of lengthy publications to explicating these ideas, but the limited scope of this paper permits only a brief introduction to their

philosophical implications. Apart from the above highlights of Bohm's quantum speculations, there remains one peculiarity that opens up a vast field for his discussion of implicate orders--the "quantum potential." Bohm postulates the existence of this potential in addition to the conventional physical forces assumed in the standard quantum approach.[23] The function of the quantum potential is best understood on the analogy of a ship guided by radar. David Pratt explains this function in a suggestive way:

> The radar carries information from all around and guides the ship by giving form to the movement produced by the much greater but unformed power of its engines. . . . The quantum potential pervades all space and provides direct connections between quantum systems.[(24)]

According to Bohm, any entity, structure, or event in an environment perceptible to humans can be viewed as a particular "subtotality," that is, as the unfolding of a deeper implicate order belonging to higher dimensions of reality. As revolutionary as this may sound, Bohm's interpretation of quantum theory admits of the existence of an immaterial world that may even exceed human nature in its intelligence and actuality. Such a mere "admission," of course, does not provide a scientific demonstration, but at least it prompts one to point out some resemblances between Bohm's approach and a doctrine that holds for a fundamental metaphysical composition not only of human beings but of the entire universe.

A first feature to be noted is the "universality" of the implicate order: in its extent it penetrates every single aspect of reality in the spatial and temporal domains. Thus it appears as an ordering by a higher intelligence, one that has mastery over all lines of causality controlling events in the most remote regions of space and time. However, to be able to exercise such a powerful function this intelligence must be radically distinct from the things

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it manages, lest it actualize its own powers and so violate the principle of contradiction. To substantiate the existence of such an intelligence experimentally, Bohm suggests that one consider that quantum mechanics, unlike classical physics, assumes that observables cannot change continuously but only according to precisely defined values. This entails the formation of a discrete spectrum in which a transition from one value to another is accomplished by gradually increasing or decreasing values through quantum steps. The immediate consequence is the following:

> Thus, if all actions are in the form of discrete quanta, the interactions between different entities (e.g., electrons) constitute a single structure of

> invisible links, so that the entire universe has to be thought of as an unbroken whole. In this whole, each element that we can abstract in thought shows basic properties (wave or particle, etc.) that depend on its overall environment, in a way that is much more reminiscent of how organs constituting living beings are related, than it is of how parts of a machine interact.[(25)]

Bohm's hypothesis of the universal connectedness represented by the quantum potential finds its confirmation in an experimental verification[(26)] of Bell's theorem.[(27)] This was inspired by the famous Einstein-Podolsky-Rosen or EPR argument for quantum incompleteness.[(28)] The theorem postulates the possibility of communication between sub-microscopic particles such as photons, separated at large distances, at speeds significantly greater than that of light. Such communication contradicts a premise of the theory of special relativity, according to which no physical signal can be propagated in the universe at superluminous speed. The EPR argument for incompleteness arose precisely from the inability of scientists to account for this literally instantaneous communication under the assumption of

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locality, namely, that there is always a limiting speed to the propagation of physical influences.

Does this constitute scientific proof for the existence of God? Certainly not. But at least it does not dispose of God in materialist-reductionist fashion, for here the question of the possible existence of some form of transcendent influence or intelligence is left open. Furthermore, Bohm's concept of implicate order correlates well with a number of other Thomistic theses. For example, any order implies the necessity of relations and, in turn, requires a complex of beings, for if all were absolutely simple, no differences could be established to form detectable relations. Whereas other physical theories such as group theory may admit of particular orders such as symmetries, Bohm's views seem to tolerate any order or composition in general, suggesting that it is not inconsistent with the most fundamental Thomistic composition of essence and existence in all creatures.

One cannot, to be sure, conclude that Bohm's quantum potential correlates essentially with all of being, but its universality need not disqualify it from functioning as a surrogate transcendental in which all things participate in an analogical way. Moreover, Bohm postulates that the quantum potential is not an ultimate intelligence, but rather is organized by a more perfect super-implicate order. Finally, he admits the possibility of an infinite series of such potentials constituting a hierarchy of generative orders with increasing perfection and causal power, as he characterizes them.

As is evident from the example of a ship guided by radar, Bohm's implicate orders continually "look after" their objects, thus operating as most intimate "maintainers" of their courses at every instant in time. In Thomistic terminology, they represent *per se* or essential causes of their effects and so cannot proceed to infinity.[(29)] A reconciliation of Bohm's theory with St. Thomas on this particular point would terminate the series of implicate orders in one that is the first and most perfect cause of all others,

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functioning in some ways as a surrogate *ipsum esse subsistens*. It would appear that Bohm's theory of implicate orders is not inconsistent with St. Thomas's ordering of all causes to a Primary Cause who is Himself uncaused and is the ultimate explanation of the entire universe. Again, this is not a mathematical proof of the existence of God. But it surely may be seen as a physical theory that is compatible with, and sees no inconsistency in, the existence of immaterial entities.

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1. W. Smith, "From Schrödinger's Cat to Thomistic Ontology," *The Thomist* 63 (1999): 49.

2. E. Gilson, *The Unity of Philosophical Experience* (San Francisco: Ignatius Press, 1999), 221.

3. *Summa Theologiae* I, q. 1, a. 3.

4. One of the most striking examples of scientism practically bordering on mythology is the Darwinian theory of evolution. The drastic imposition of stochasticism on the vital mechanisms of natural generation with minimal experimental evidence seems more like an attempt to carry out a deliberate philosophical agenda than an honest scientific investigation. A solid refutation of Darwinian theory based on microbiological and biochemical evidence can be found in Michael J. Behe, *Darwin's Black Box: The Biochemical Challenge to Evolution* (New York: Touchstone, 1996).

5. Aristotle, *Physics* 2.2.193b31-35.

6. A. N. Whitehead, *Adventures of Ideas* (New York: The Free Press, 1967), 115.

7. J. A. Weisheipl, *The Development of Physical Theory in the Middle Ages* (Ann Arbor, Mich.: University of Michigan Press, 1971), 60.

8. I *Post. Anal.,* lect. 25, n. 6.

9. W. Smith, *The Quantum Enigma: Finding the Hidden Key* (Peru, Ill.: Sugden, 1995). For a review of this work from a Thomistic viewpoint, see William A. Wallace, "Thomism and the Quantum Enigma," 61 (1997): 455-67.

10. *In Boet. de Trin.,* q. 5, a. 3.

11. See Smith, "From Schrödinger's Cat to Thomistic Ontology," 53.

12. Ibid., 52.

13. Ibid., 57.

14. The formulation of quantum mechanics, and particularly Schrödinger's equation, has undoubtedly revolutionized modern physics. Although preceded by many experimental results, such as the discovery of black body radiation, the photoelectric effect, and the discrete emission spectra of the hydrogen atom, quantum mechanics itself has largely been derived from abstract mathematical premises. In this respect one might regard it as a product of dialectical reasoning.

15. *In Boet. de Trin*., q. 5, a. 3, ad 5.

16. Ibid., ad 6.

17. L. J. Elders, *The Metaphysics of Being of St. Thomas Aquinas in a Historical Perspective* (New York-Cologne-Leiden: E. J. Brill, 1993), 278. Reference is made to the original publication by L. DeBroglie, *Nouvelles perspectives en microphysique,* 226.

18. D. Z. Albert, "Bohm's Alternative to Quantum Mechanics," *Scientific American* 270 (May 1994): 58.

19. I *De Caelo,* lect. 3, n. 6.

20. W. A. Wallace, "A Thomistic Philosophy of Nature," in *From a Realist Point of View: Essays in the Philosophy of Science,* 2d ed. (Lanham, Md.: University Press of America, 1983), 39.

21. W. A. Wallace, *The Modeling of Nature: Philosophy of Science and Philosophy of Nature in Synthesis* (Washington, D.C.: The Catholic University of America Press, 1996), 72.

22. Ibid., 57.

23. D. Bohm, "A Suggested Interpretation of the Quantum Theory in Terms of 'Hidden Variables,'" *Physical Review* 85 (1952): 166.

24. D. Pratt, "David Bohm and the Implicate Order," *Sunrise* 42 (February/March 1993).

25. D. Bohm, *Wholeness and the Implicate Order* (London, Boston, and Henley: Routledge and Kegan Paul, 1980), 175.

26. D. Bouwmeester et al., *Nature* (11 December 1997): 575. This experimental procedure, also called "quantum teleportation," was performed by physicists at the University of Innsbruck, Anton Zeilinger and Dik Bouwmeester.

27. J. S. Bell, *Physics* 1 (1964): 195.

28. A. Einstein, N. Rosen, and B. Podolsky, *Physical Review* 47 (1935): 777.

29. *STh* I, q. 46, a. 3.