THE CORRESPONDENCE BETWEEN HUMAN INTELLIGIBILITY AND PHYSICAL INTELLIGIBILITY: THE VIEW OF JEAN LADRIÈRE

by Kam-lun Edwin Lee

Abstract. This article seeks to explain the correspondence between human intelligibility and that of the physical world by synthesizing the contributions of Jean Ladrière. Ladrière shows that the objectification function of formal symbolism in mathematics as an artificial language has operative power acquired through algorithm to represent physical reality. In physical theories, mathematics relates to observations through theoretic and empirical languages mutually interacting in a methodological circle, and nonmathematical anticipatory intention guides mathematical algorithmic exploration. Ladrière reasons that mathematics can make the physical world comprehensible because of the presence of a rational principle in both kinds of intelligibility.

Keywords: correspondence; formalism; intelligibility; Jean Ladrière; linguistic philosophy; rational principle.

Arthur Peacocke in his article published in this journal confessed that his discovery of the intelligibility of the natural world through scientific investigation led him to infer the existence of some "suprarational" ground, which he identified as "God" (Peacocke 1994, 642–43). This inference is Peacocke's personal testimony that the inquiry of scientific realities need not negate theological realities; on the contrary, scientific research led him to marvel at the intelligibility that demands an explanation pointing to God's existence. Arguing against methodological reductionism being practiced by many in the scientific community, he aimed to justify that theology, irreducible to other disciplines, has a rightful place on the map of knowledge (Peacocke 1994, 644–50). Peacocke was

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certainly correct to affirm that reality exists at different levels and that theology cannot be restricted within the boundaries of psychology, anthropology, or sociology. His personal claim of the existence of a suprarational ground, however, invites a substantiating reflection on how intelligibility is possible. Although a confirmation of the existence of such a ground is not yet a proof of the existence of God as a personal deity (since the former only concerns the nonpersonal rational principle), such confirmation will strengthen Peacocke's case by showing that reality is a complex whole. The inquiry into the intelligibility issue will lay a philosophical foundation based on which the relation between the suprarational ground and God may be further investigated at the cosmological level. Focusing on the disciplines of mathematics and physics, Jean Ladrière has attempted, in his various writings, to explain the intricate process of intelligibility. To help substantiate Peacocke's inference, this paper will present a synthesis of Ladrière's view. (References including only dates and page numbers refer to Ladrière's work.)

How can physical theories formulated in mathematical terms predict experimental results?[1] Working in mathematics is a mental activity, but doing experiments involves observation of the physical world. Assuming the two are congruent seems to imply that human reasoning is somehow linked to the ground of intelligibility of the physical world. Ladrière points out that mathematics, owing to the objectification function of symbolism, is endowed with an operative power that when applied to physical theories can work to reconstitute the physical reality. Moreover, the reason mathematics can be used in physical theories to interpret the empirical world is that the rational principle is inherent in formal reasoning as well as immanent in the world. We will focus on three themes developed in the thought of Ladrière: (1) the operative power of formalism in mathematics, (2) the application of mathematical formalism to the empirico-formal science of physics, and (3) the rational principle and ontology. The first deals with human intelligibility in formal thinking. The second addresses the issue of how human intelligibility can comprehend the intelligible world through use of formal construct. The third tries to answer why there is concord between human intelligibility and the intelligibility of the physical world.

The Operative Power of Formalism in Mathematics

To understand the operative power of formalism, we must ask what formalism is, by what means it acquires its operative power, and what the world of mathematics is like.

1. FORMALISM AS AN ARTIFICIAL LANGUAGE. Formal thought is distinguished from nonformal in that, while the latter must refer to the

object through some kind of intuition (such as perception), the former is pure thought and therefore coincides exactly with the object contemplated. In a sense formal thought "reduplicates itself entirely in the act of its effectuation" (1972c, 126). Thus, a formal system is detached from life experience and is a reality in the ideal order. This is useful for our understanding of the phenomena of our world. This system permits the exploration of many possibilities in abstract space without involving the physical rearrangement of objects (1974b, 296). More, a formal system is an artificial language defined syntactically by a system of rules that allows a person to decide the truth value of a certain sentence procedurally (1972d, 19). In other words, formalism permits us to determine with certainty, through a step-by-step process, whether a proposition belongs to the truth domain already created by that formalism. By means of strict and complete rules, operations can be performed to augment that domain of pure thought; what an operation does is to effect the "pure relational schemas" (1972c, 122, 127).

Unlike the signification of each lexical entry of a dictionary, that which is derived from a formal system seems inexhaustible. A formal system could unfold ever new meanings as the exploration—controlled by *internal requirements*—continued without ceasing (1972e, 64). Indeed, meaning is generated in a formal system when, on one hand, a rightly constructed expression conforms to the formational rules of the system and, on the other hand, it fits into the relations of the network formed by other derived expressions (1957, 40). It appears that formalism has a life of its own independent of our daily experience. It is free to acquire its power from its mechanically operative ability.

Nevertheless, no matter how powerful a formal system is, it is without interest if it is not related to a domain of objects. Our concern here is specifically mathematics as a domain of reference that deals with ideal objects such as numbers, sets, algebraic structures, and spaces (1972d, 20–21).

2. FORMAL SYMBOLISM. The real fruitfulness of an idea commences only when an algorithm is invented. The case of infinitesimal calculus is an example. If formalization makes a mechanical algorithmic operation possible, this is a result of the thematization of the operation by use of symbolism (1972e, 51–52). This point distinguishes formalism from ordinary language, in which there is a fusion between all the elements of a discourse (1957, 435).

A formal symbol is a basic unit in the artificial language of formalism, and its only function is to make abstract formal structures accessible to human consciousness. As a tool for presentation, formal symbols are only conventional. They are necessary to make formal structures manifest, but no one particular set of symbols is irreplaceable (1972d, 18–19; 1972e, 48). Symbolic language is indispensable in formal operation because it has a dual property. On the one hand, symbolism presents itself as an object independent of human consciousness and accessible through perception. On the other hand, it could present again the steps of the mental act that take place within the human mind. Hence, through objectification by way of symbolic presentation, the steps of mental acts can be systematically analyzed with rigor (1957, 439).

To illustrate the use of formal symbols in an operation, let us refer to the generation of whole numbers. Whole numbers may be generated by defining an operation of which an initial object, say *o*, is operated on successively by a predicate, say *S*. By repeating the process, an infinite series of ideal objects can be generated as follows: *o*, *So*, *SSo*, and so forth. When interpreted with reference to the mathematical domain, these ideal objects correspond to whole numbers of 0, 1, 2, and so forth. Here, via the use of formal symbols, the seemingly unmanageable infinity characteristic of the whole number series can be captured (or thematized) in the repetitive application of the generative algorithm.

However, we have more than one way to express the ideal objects of whole numbers, in fact, an infinite number of ways, depending on the base chosen. Thus, the ideal object designated by *SSSo* could be equally expressed by 3 in base ten and by 11 in base two. Likewise, a certain rational number such as 1/3 can also be expressed by 0.333. . . .

When we move beyond symbolic designation of numerical objects to algebraic reasoning, the use of symbolism is even more fruitful. This reasoning has moved one to consider the operation per se that leads to the development of abstract algebra. At a higher scale of abstraction, beyond that of abstract algebra, operations become more and more detached from any immediate reference to objects to be operated on. The most abstract discipline at present is combinatory logic, which is a study of formal operations called *combinators* (1972e, 46–57; 1972c, 123).

3. INTERNAL FECUNDITY OF THE MATHEMATICAL DOMAIN. By means of symbols, the operative power of formalism can be put to work. This operative power opens up a world of unlimited riches.

An Inexhaustible Domain. Exploration of the mathematical domain reveals that it has no known a priori boundary. This condition might be hinted at when we turn to the study of axiomatic systems. As in all formal sciences, axiomatic systems are especially important in mathematics because of their explicit structures, and some problems can only be treated by axiomatic method. Through the application of deductive rules to the axioms, all the true sentences can be generated. It has been noted, however, that not all parts of mathematics can be formulated as axiomatic systems and that axiomatization is always conditioned by a reality beyond the system itself. This inadequacy in axiomatic systems points to the fact that, however important the method may be, it is impossible to determine the whole of the mathematical domain once and for all (1972d, 19; 1966, 221–22).

More generally, Gödel's theorem seems to point in the same direction. The theorem may be stated as follows: "In any formal system adequate for number theory there exists an undecidable formula—that is, a formula that is not provable and whose negation is not provable" (Van Heijenoort 1967, 348). In order to clear up common misunderstandings concerning the theorem, Ladrière explains what it does not mean. Gödel's theorem does not say that there is something wrong with the formal method nor that there is a hidden contradiction at work in a formal system (1957, 404–5). Instead, the theorem says that a strictly deductive approach can cover only a limited field of formal reasoning. As a result, intuitive truth is indispensable in formal constructions (1957, 410–13). This intuitive power makes an infinite extension of the mathematical domain possible. In each of the terms that can be effectively attained, there exists implicitly the possibility of arriving at a new horizon beyond the present one. As an example, Georg Cantor's transfinite numbers are constructed when the limit of denumerable infinity is conceived. They are not arrived at by deduction (1957, 440–43; cf. George Gamow 1953, 25–34).

Possibility of Progress. With no a priori boundary to the mathematical domain, progress can be made under three conditions—schematization, thematization, and disengagement. With schematization, one begins with a certain concrete case that is readily accessible to perception or intuition, and one varies the individual aspects of that case until a more general scheme, which underlies all variations, is obtained. As an example, topology is originated from the problems generated by common geometrical objects such as a sphere and a torus. In *schematization*, one starts from some very elementary concepts to form more complex mathematical ideas on which perception no longer has any influence. Through generalization or comparison, one can discover new mathematical objects. Therefore, once the concept of one dimension is defined, other higher dimensions can easily be generated mathematically. With *thematization*, one posits a theme on a theory of a certain level in order to build up the content of a theory at a higher level. The lower-level theory serves as a kind of experiment for the formation of the higher-level theory. For instance, the theory of groups of transformation is a systematic study of operations that one uses in various geometries. The theory brings together the seeming diversities into one general framework. In *disengagement*, one schematizes the common characteristic traits of various theories to form a domain of more generalized formal objects. Just as in the case of general topology, the basic ideas are related not only to the study of topological properties of figures but also to the study of real variables.

In all three situations, we see a common process of detachment from the concrete and an attempt to look for the common underlying structure and the representation of new objects by appropriate formalisms. It is a process from the particular to the general through abstraction. Progress of this upward movement also helps progress in the downward direction, however, for only when the general theory is known can the particular be better understood and applied in concrete situations. "The being" of mathematics is not static but is always "the becoming" (1966, 227–28, 230; cf. 1972d, 22).

Possibility of Mutual Exchanges. Another sign of the internal richness of mathematics, besides the possibility of progress, is the possibility of mutual exchange between branches of mathematics. One of the phenomena is autoapplicability, which is to say that one branch of mathematics can solve the problem of another branch. Hence, the algebraic question of quadratic forms is solved by repositing the problem in terms of conic sections, and the problem raised by the equations of the fifth degree can be treated by group theories. Mathematics seems to have provided for itself instruments in some parts of the mathematical domain to solve its own problems even before a question is raised. Ladrière calls this "retrospective fecundity" (1966, 231).

The possibility of mutual exchange indicates that areas covered by different branches of mathematics or systems of formal representations may overlap. This assumption seems to be supported by the observation that there exists a plurality of axiomatic approaches to the same problem (1966, 218–19). The reason is that different formulations are systems of symbolic representations referring to the same reality, not the reality itself.

Possibility of Unification. If there are exchanges between different parts of mathematics, do these parts then make up a whole? Since there is no a priori limit to the mathematical domain, there should not be a preexistent whole prior to formal construction. With the dynamic nature of becoming in regard to mathematics, however, there is a unification process presupposing a common foundation for all branches of mathematics. To date, the most promising theory for establishing this foundation seems to be set theory.[2] As mathematical unification continues to progress, a complete unity may be viewed as a "limit situation" (1966, 231–32).

In conclusion, we may say that mathematics forms a synthetic system within which ever new objects can emerge as the unending exploration continues. This synthesizing character makes the mathematical world akin to the physical world, which again upon investigation has the property of incessant unfolding.

THE APPLICATION OF MATHEMATICAL FORMALISM TO PHYSICS

Although the application of mathematical formalism is not limited to physics, physics is the most basic and representative of all other branches of empirico-formal sciences. Here again we ask: In what manner can the outcome of mental activity be useful to the understanding of physical phenomena that have no direct link with the human mind? Although modern sciences do not answer the ultimate question of why mathematics can be applied, they have made assumptions about nature so as to make application possible. Under these assumptions mathematics is related to observations through two languages—namely, theoretic and empirical languages. Scientific theories progress via the interactions of these two languages in a methodological circle, yet mathematical formalism demonstrates its real power in the theoretic conceptualization process.

1. THE PRESUPPOSITIONS OF PHYSICS AS AN EMPIRICO-FORMAL SCIENCE. In modern sciences such as physics, the assumptions made about our physical world are connectivity, closure, reducibility, mathematization, empiricity, and emergence. *Connectivity* assumes that all natural events are directly or indirectly linked with one another. *Closure* supposes that all events in nature can be explained by other events of nature. *Reducibility* states that all particular events and figures manifested as physical phenomena can be interpreted in terms of, and hence reduced to, interactions. *Mathematization* asserts that the interconnectivity of events governed by the principle of regularity can be formulated as laws in mathematical terms. *Empiricity* grants that all the propositions can be proved by means of local observations. And finally, *emergence* presumes that a higher level of reality may emerge from a lower one (1987, 16).

Although the assumption of emergence may not have any conceivable direct bearing on the applicability of mathematics to the study of physics,[3] others have important implications. If connectivity presupposes a logical universe, then closure assumes no other causes except those within the physical universe itself. Whereas reducibility assumes the possibility of schematization of physical phenomena, mathematization takes for granted the possibility of formalizing what is schematized. And last, empiricity takes advantage of the universal regularity in the universe to make local observation representative of all other possible observations under the same controlled conditions. In sum, we may say that in order for mathematical formalism to be applicable to the understanding of the physical universe, we have to assume a logical universe (1974a, 235).

2. APPLICATION OF FORMALISM IN THEORIES. In agreement with the above presuppositions, a physical theory can be expressed in terms of mathematical formalism. The fact that physical theories are built on formal constructs may be testified to by both classical and quantum theories. On the classical side, Newtonian mechanics postulates the existence of space, particles, and forces in the inertial frame. That conception of the universe, however, is replaced by Einstein's theory of general relativity, which reduces forces to space curvature (1972a, 165). The very extension of meaning from Newtonian to relativistic mechanics has presupposed a dilatable universe of reference made possible by formal constructs. (1974a, 233–34).

When we come to quantum theory, we may think that the randomness of quantum behavior does not allow us to use formalism. Yet, despite seemingly unruly behavior in the quantum world, one can use the "wave-function," a formal construct whose exact meaning is not yet known, to make useful predictions about its state of affairs (1972e, 61–62). In Ladrière's words: "If we regard the state of the system as determined by the wave-function, we then recover an unambiguous connection between states" (1970b, 74).

Even though both classical and quantum theories employ formalism, their approaches are radically different. In the presumably deterministic classical theories, what is expressed in formalism is an ideal situation in which experimental errors are not included and so must be considered separately. In the intrinsically statistical quantum theory, the formalism incorporates observational errors into itself (1970b, 74).

A physical theory nonetheless is not just mathematics; it always has an added semantic dimension of the physical world. This is well illustrated by the consistent use of models that translate mathematical formalism into meaningful scenarios. A model is a mathematical construct that approximates the conditions of a certain physical phenomenon (1974b, 289; 1986, 44). On one hand, a model represents a domain of realization in which theories can be confirmed; on the other hand, it represents a provisional schematization of the situation (1977, 95). Thus, if the transparent scheme of mathematics is substituted for the opaque reality of physical phenomena (1977, 98), a model makes the reality operatively intelligible and the scheme physically meaningful.

Moreover, it is understandable that nonmathematical axioms can play a very important role in physical theories. As a case in point, the principle of dynamics, which expresses the proportionality between acceleration and force, can never be obtained from mathematics alone. In fact, this type of consideration, which is based on a certain opinion about the working of our universe, has a normative character even to the extent of controlling the choice of mathematical formalism employed in the theory. The belief in the principle of invariance actually governs the development from Newtonian mechanics through relativity to quantum mechanics. In Newtonian mechanics the concept of inertial frame, in which physical laws are applied, is based on the belief of invariance under Galilean transformation that leaves out the consideration of time. In general relativity the liberation from the classical understanding of inertia is built on the belief of invariance under the transformation of space-time. And in quantum mechanics the central issue of symmetry, which governs the behavior of the fundamental physical quantities, is an even more general notion of invariance (1986, 34–36).

Besides the principle of invariance, the principle of causality also contributes very much to the advancement of physical theories (1972a, 185). Whereas the former principle points to harmony in nature, the latter refers to a stable universe; yet both bear witness to the more general principle of conservation (1970b, 78–80; 1974b, 298–301).

3. THE TWO LANGUAGES. Unlike mathematics, an empirico-formal science such as physics involves two languages: "a theoretic language to express certain relations of general order between the entities and properties in terms of which one can analyze the reality to be studied, and an empirical language to describe the empirically observable aspects of this reality and the possible operations on it" (1972d, 23). The theoretic language has theoretic terms referring to entities or to properties that may not be observable, such as *electromagnetic field* or *inertial mass*. The empirical language also contains empirical terms that concern observable entities and properties, such as length or weight. All these terms in both languages are not derivable mathematically although both make use of mathematical tools.

In order to bridge the two languages, correspondence rules must link a theoretic term to a measurable, empirical one. For example, the idea of temperature in the theory of thermodynamics may be linked to the measurement of temperature by a thermometer according to correspondence rules. Basically, a physical theory is made up of two sets of propositions that are assumed true unless shown otherwise: the first is a set of axioms from which other theorems may be deduced, and the second is a group of correspondence rules. What amounts to an explanation is a successful deduction made from the axioms and, when translated into empirical terms by correspondence rules, found to be in agreement with the observed results in the context of the reality in question—namely, the *initial conditions*. Hence, a physical theory, though formulated mathematically, always anchors in the physical reality (1972d, 22–25).

4. THE METHODOLOGICAL CIRCLE. Truth in physics is not a given but a becoming. In the methodology of physics, there is a circularity toward truth (1972d, 43). In accordance with the two languages, this circle has two methodological moments. The theoretic moment is a priori in the sense that it is a provisional logical construct governed by general principles (such as the conservation principles and variational principles) built on the assumption of the intelligibility of nature. This theoretic moment is nothing less than a potentially anticipatory precomprehension of the domain under investigation. The empirical moment is, however, affected by the choice of formalism employed in the theoretic moment—in the sense that, through the use of correspondence rules, this choice controls the way data are taken and interpreted. Therefore, naked empirical truth does not exist, and all observational propositions are revisable. Thus, the object is reached only through theoretic interpretation (1972d, 29–31). The methodological circle, however, does not stop here, for theory must be verified by empirical experience (1972d, 27–28; 1972b, 83). Although observation may be compared to an *indicator*, theory can be viewed as a *resonator*. If the theory is a correct "conjectural reconstruction of reality" at least for a certain domain, scattered local observations will be able to touch off a resonance in the theory that covers the "continuum of reality" (1972d, 32).

Yet theoretical prediction may not always agree with the observed result, or the theory may suggest a situation for which it cannot give an interpretation. These situations may be termed "the condition of integration," which calls for a revision of the internal configuration of the theory in order to overcome the contradiction or to close a gap. Repeating the process of the methodological circle integrates more and more varied aspects into the theory, and it becomes more autonomous with respect to the environment (1974b, 303–4).[4]

In the methodological circle, although empirical verification is indeed indispensable, the meaning does not lie there but, rather, in the theoretical act of constituting (1972a, 170).

5. THE THEORETICAL ACT OF CONSTITUTING. Ladrière believes that in the reconstitution of reality the manifestation movement is rearticulated. Through the act of constituting, the interconnectivity or "concatenation" between phenomena may be traced (1952, 33). As the theoretical "terms are connected by a connecting operation," meanings are engendered through the seizing of this operative movement (1972a, 170). In the horizon of operation, one may preview the world as "a regulated system of interactions" and analyze its "enchained elementary actions" according to their "intrinsic nature" (1952, 36). In the reconstitution of reality, operation in a physical theory possesses the prospective power to

explore the unknown world, because the logic which is supposed to be immanent in nature may be reeffectuated in the abstract schema in the act of reconstituting (1972c, 134; 1974b, 288). The content of the theoretical reconstitution "is extended presumptively to cover regions still unexplored" (1972d, 27–28), hence we may "anticipate experience" and "intend a not-yet-present reality" (1972b, 83).

Such a previsional power of a physical theory as a "conceptual system" (1972a, 171) is a result of "the formalization of an anticipatory intention, of a foreunderstanding of the domain [of investigation]" (1972d, 28). The recourse to formalization grants the foreunderstanding a precise content and an operative status so that the power of algorithm may be exploited (1952, 34). Conversely, the foreunderstanding is always present in the formal operation (1972d, 28–29) to give the latter physical intention as well as guidance when nonmathematical decisions have to be made (1977, 94). These decisions include even the choice of the proper formalism itself (1986, 33–34). Formalism *admits what is possible*, prior to experience, regarding the characteristics of the physical phenomena studied (1972e, 60; 1971, 258–59), but by nature it remains *underdetermined* with regard to reality (1986, 32).

The inherent use of mathematical formalism in the conceptualization of physical theory means that there exists an internal exigence within the concept that pushes for the advancement of theories in the right direction (1977, 94; 1986, 43). For instance, the transition from the theory of Newtonian mechanics to that of relativistic mechanics is not a result of subjective initiative but of the internal structural requirements indicated by fruitful contradictions, even prior to the conscious comprehension of the new situation (1972a, 171–72).

In what way is mathematical formalism applied to the study of physics? This is not a simple question to answer, but clearly its most fruitful application is in the conceptualization of theories. Although foreunderstanding guides the algorithmic exploration, mathematics gives foreunderstanding the operative power. Together, in formalizing the foreunderstanding or anticipatory intention, we endow the physical theories with predictive power.

THE RATIONAL PRINCIPLE AND ONTOLOGY

We have seen *how* formalism is applied in physical theories; now we are to inquire about *why* that is possible. Our reading of how formalism is applied in the physical universe seems to suggest that there is indeed a metaphysical connection between mathematical thinking and the logic immanent in physical phenomena. In order to address this question, we ask whether there is a dynamic relation between form and matter, how the two may be structurally linked, and what prospect there is of showing the correctness of the structure. More, granting that the structure is as proposed, we need to ask how physical manifestation is made possible.

1. TRAFFIC BETWEEN FORM AND MATTER. In the study of physics, the quantities in the hypotheses of the theory are associated with an implicit ontological hypothesis in the sense that we expect to see in the empirical world the existence of entities possessing the properties projected by the theory (1971, 254). Physical theories as conceptual systems are reconstituted realities, and the reconstituting movement is the reverse of the manifesting movement. We may therefore be able to understand more fundamentally how physical manifestation takes place. This upward movement shows us that, beyond the naked appearance in things, there is a deeper meaning that may be made explicit by articulation consonant with an internal structure immanent in what is manifested (1988, 249; 1984a, 2 : 219). This structure is logical, not just in the sense that it is merely the set of rules governing coherent discourse, but, more importantly, in the sense of what Martin Heidegger has in mind: "a 'bringing together' which makes appear" (Ladrière 1972e, 65). In Ladrière's own words,

> It is an act of selection and liaison which accompanies things in their coming to presence, which, with them, retraces the way of their manifestation. The movement that inhabits discourse is the same movement that inhabits world; it is its setting forth, its original blossoming, its genesis and its growth. *Logos* [the rational principle] is *physis* [nature as originating power]. But *physis* is itself *ousia* [essence]; it is that which brings things into presence; it is generative of the universal parousia. As such it indicates how things are called into the partaking of presence, into the confines of being. *Logos* is thus also ontology. (1972e, 65)

In Ladrière's understanding the rational principle *logos*, which is charged with meaning, is autonomous and possesses its own exigence to realize itself by conforming to its own law. To achieve this end, it operates both in human formal reasoning in the reconstitution process and in the manifestation of physical reality so that what is manifested may be comprehended (1977, 104–8). In formal reasoning, therefore, the rational principle prescribes what is possible or admissible in the real appearance of things (1981, 74, 76). The production of things takes place when all the prescribed conditions are satisfied or, in other words, "if determinations reach the point of saturation" (1970b, 100).

As such, the stability of things is only relative and temporary, subject to the opposing movements of degeneration and the emergence of organization. Ladrière quotes Alfred North Whitehead: "Nature is 'passage'" (1988, 254–55). It is "passage" in the sense that things appear and disappear in the field of manifestation. The field "bears within it (as a field) the becoming, the blossoming, of the thing," and "the full presence of the thing consists in the achievement of the act of appearing" (1970b, 96). As each thing appears, "the entire field in which it appears is assembled and produced while this field produces the thing" (1970b, 96–97). The dynamic relation between form and matter leads Ladrière to conclude this: "Form is not, in any case, frozen; the concrete is not closedness. Perhaps between things and forms, between names and figures, between signs and substance, there is increasing traffic, a universal and permanent symbolization"[5] (1972e, 65). The existence of things in themselves is certain, though they are neither permanent entities nor objects of knowledge. Their reality is only guaranteed by the prescription of the rational principle, and meaning engenders when the manifestation process is reconstituted.

2. A PROPOSAL OF THE FOUNDATIONAL STRUCTURE: PROCESSIONAL MODEL. This logical structure inherent in reality, which gives the world its texture, is what Ladrière calls "the a priori" (1972a, 180). It is the condition that transcends the thing itself yet controls the ontological unfolding of things as we see them. Ladrière compares this unfolding to an emanating procession whereby the multiplicity of the physical world is generated through successive layers of constitutive conditions. The layers are the highest level, general ontological categories; the middle level, formal ontology; and the lowest level, individuating principles. So the procession goes from metaphysics through mathematics to physics, and by means of the individuating principles the concrete reality in multiplicity may be comprehended. Conversely, in retracing the movement through reconstitution, we may consider that "the reality of mathematics is that of an ontological *a priori*" at the formal level (1966, 236–38).

3. THE PROSPECT OF SHOWING THE CORRECTNESS OF PROCESSION. Ladrière believes that it may become possible to show the model of procession to be the correct hypothesis if one can demonstrate that mathematics is the preconditioning a priori for the physical constitution of the world. This demonstration requires the showing of correspondence between the whole of mathematical reality and the whole of the physical reality. But at the present stage of development, the relationship of mathematics to physical reality is still underdetermined. It is only at the limit of the movement toward "totalization," or attainment of the total virtual system, that the correspondence may be realizable (1966, 239; 1957, 410, 437). Because only separate partial formal systems are now available for the study of physics, we can at best build particular physical laws to comprehend our universe in a piecemeal manner. In a certain sense, partial knowledge is a "limit-idea." "The true reason for the intelligibility possessed by particular laws is due not to their applicability to

experience but to their conformity to a universal principle" (1970b, 76).

But how possible it is for us to attain the total mathematical reality, the absolute formal field? With operations used in formalism, the content attained is bound to be partial because such operations are by nature analytic and can deal with only one thing at a time. At present, instead of having one single unified formal system, we have a multiplicity of partial systems that can move between one another. This possibility of mutual exchange between partial systems implies that they are of the same order of reality. The total system represented in formal construction is not forthcoming and perhaps not possible, yet that total system of unlimited possibilities is being approached by each partial system.

But what could approaching totalization possibly lead to? According to Ladrière's speculation, the more progress toward the total virtual system, the closer the approach comes to the concrete, because totalization means concretization. If a total system could be constructed, "it would effect simultaneously all conceivable connexions" (1972c, 127). The absolute formal field that may still be a virtuality to us will become actual and "enter so to speak into a visible body of effectuation" (1972c, 128). Moreover, if a total system could be constructed, it would mean reaching "the fullness of logical existence," a condition under which the physical realization is close at hand (1972c, 128). Ladrière does not mean to say that formal reasoning at the limit of totalization can make things appear physically, but he maintains that we will be illumined to see the full picture of all the logical conditioning connections that lead to physical manifestation.[6]

4. THE DYNAMICS OF PHYSICAL MANIFESTATION. As regards the movement of physical manifestation, the thing is "passage" in the sense that it is produced from the entire field of manifestation and is taken back into that "totality" (1970b, 97). It is the differentiating movement from unity to multiplicity, however, that brings things into being. Through such a movement, all the differentiated entities are again unified under the influence of the unity. Thus, the differentiating movement is at the same time a unifying movement. Yet, in going from one pole to another, these movements must pass through the medium of structural relation (or the a priori), which can be further classified as "spacelike" with reference to "conditions of stability, configurations, nature as architecture" and "timelike" regarding "connection, process, nature as melody" (1970b, 97). Through structural relation, the original undifferentiated unity may "be produced as an organized unity," which is nature itself, and this organized unity is the synthesis between the generating origin and the things generated (1970b, 98).

However, in the coming and going between the original unity and the organized unity through structural relation, there is a stabilizing factor—each real thing that appears. By means of action, the thing must "sum up in itself the entire universe, the system of all things" (1970b, 98). Nevertheless, each particular thing on its own is only a "provisional concretization," and the "true concretization" involves nature as a whole in unending self-production. Hence, the thing is never stable and can only be "a becoming" in its universal action (1970b, 99).

Closing Thoughts

The existence of a suprarational ground inferred by Peacocke has found substantiation in our investigation into how intelligibility is possible. Ladrière's contribution presented in this paper centers on the idea that intelligibility lies in the act of reconstituting reality. (The reconstituted reality, identified as the "third world," is distinguished from the mental world and the physical world [1977, 106]). Both the act of reconstituting and the process of physical manifestation are governed by the same rational principle, the common suprarational ground of intelligibility, which has its own objective reality. On the one hand, Ladrière's view contrasts with Emmanuel Kant's subjectivism, which holds that the logical structure immanent in the physical phenomena is nothing but a creation of the human mind (1986, 40). This explains the congruence between human reasoning and nature, at the cost of reducing all reality to the realm of the knowing subject. If the human mind is taken to be the ground of intelligibility, what is known or can be known loses its objective character, and no court of appeal for truth exists. On the other hand, Ladrière opposes the neopositivists' empiricism, which claims that nothing more can be known except what can be perceived (1972b, 81), thereby reducing the locus of intelligibility to sense data. If one were to adhere to strict empiricism, there would be little progress in scientific research. This is because a human being lacks the power to see beyond the immediate and derive intelligible meaning out of naked sense data.

Peacocke has further identified this suprarational ground with "God" (Peacocke 1994, 643), but Ladrière is more sensitive to the different kinds of questioning represented by the disciplines of philosophy and cosmology, and hence affirms that the gap between the rational principle and God as a person Diety is still large (1984b, 129). Nevertheless, by addressing the issue of intelligibility, we have contributed to the laying of the philosophical groundwork, based on which further questions at the cosmological and theological levels can be asked concerning the relation between God and the suprarational ground (cf. 1972a, 172–74).

Notes

1. A classic example is Einstein's general theory of relativity, which was constructed mathematically in 1916, decades before it was first confirmed experimentally by a Hungarian physicist, R. von Eötvös, and later in the 1960s, by an American physicist, Robert Dicke (Bergmann 1977, 585–86).
2. Ladrière recounts past unsuccessful attempts to consolidate the theoretical grounding of set theory and concludes that the search for such a foundation of set theory is still open (1970a, 450–76).
3. In fact, the assumption of emergence throws an acausal factor into the picture, but spontaneity is part of the physical world as is possibly the case with quantum mechanics (1972a, 183, 185).
4. What this result could mean is that fewer parameters need to be determined empirically in a highly integrated theory, for the information carried by those parameters may be obtained from the newly integrated aspects.
5. According to the context of the French text, the meaning of *symbolization* probably should be understood etymologically as a "throwing together."
6. To Ladrière, for the world to become visible is for it "to enter the visible domain, not in the sense of the visual field, but in the sense of an illuminated domain within which vision is possible" (1972a, 176).

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