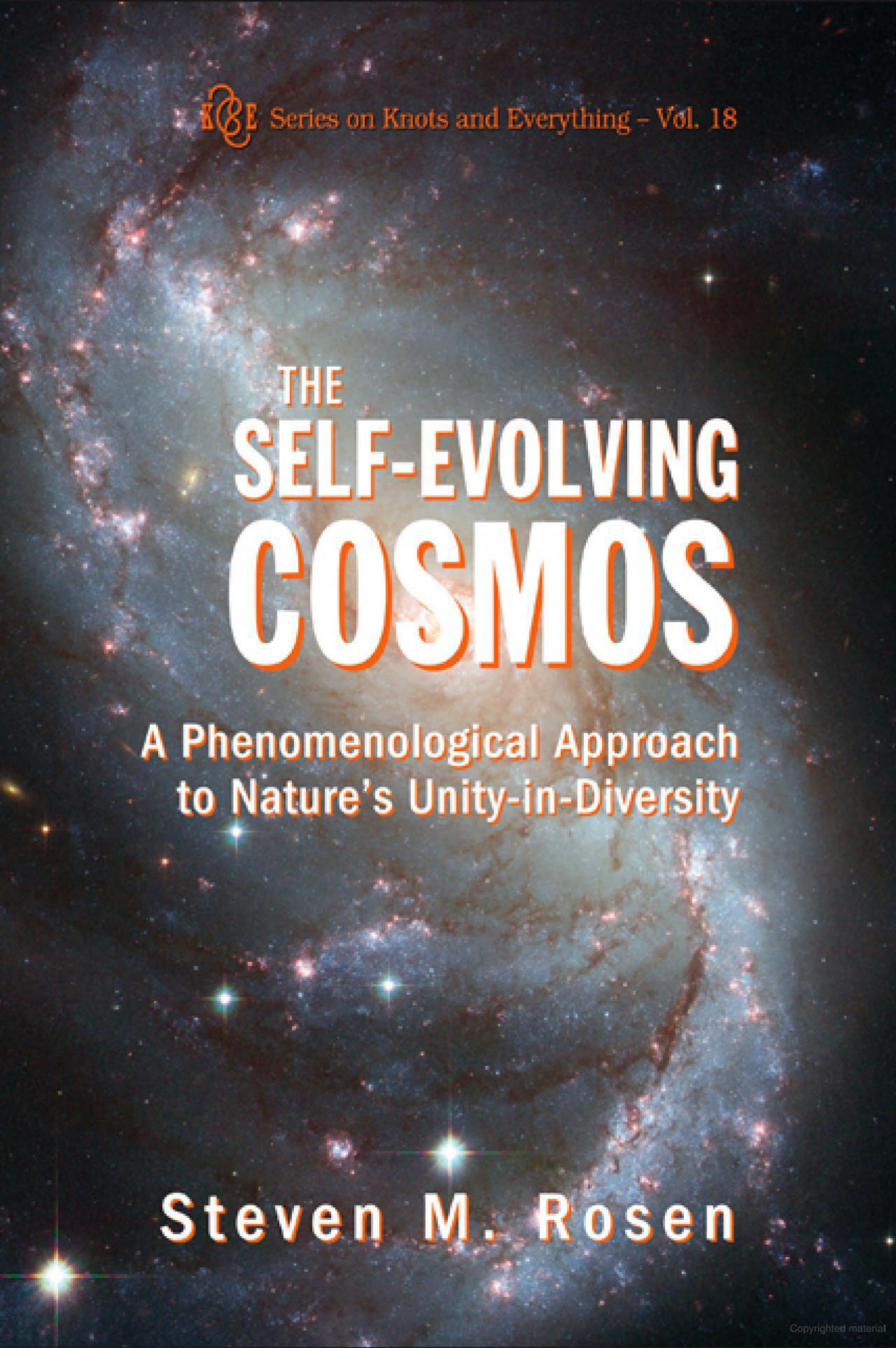

K&E Series on Knots and Everything – Vol. 18

THE SELF-EVOLVING COSMOS

A Phenomenological Approach to Nature's Unity-in-Diversity

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City University of New York, USA

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Preface

After hearing a lecture by his younger colleague Wolfgang Pauli, the renowned physicist Niels Bohr is said to have commented: "We are all agreed that your theory is crazy. The question which divides us is whether it is crazy enough to have a chance of being correct. My own feeling is that it is not crazy enough."

Many contemporary physicists acknowledge that the phenomena of their field are so odd, the problems so befuddling to our current ways of thinking, that only a completely "crazy" theoretical approach to them has any possibility of success. What I suggest in the present book is that resolving the problems of modern physics may require something "crazier" still — not just an entirely new theory, but a whole new philosophical base, a new way of intuiting the world. We are going to see that while a spate of "crazy" theories and concepts have been put forward by physicists to account for the fields and forces of nature and their evolution, all theorizing has been tacitly grounded in a set of philosophical presuppositions and postures cast in the classical mold and never opened to question. I intend to show that it is not so much an absence of the right theory that has frustrated physicists' attempts at a comprehensive understanding of the natural world, but the unacknowledged presence of deeply engrained assumptions about that world that are essentially incompatible with the radically non-classical phenomena underlying it.

In subsequent chapters, I will explore in depth the philosophical suppositions of contemporary physics and will develop in detail a proposed alternative. By way of introducing my approach in this preface, I would like to briefly situate it within the recent history of the philosophy of science.

In the first half of the twentieth century, philosophy of science was governed by the analytic tradition of logical positivism. Here "philosophers of science viewed their job as formalizing the methods of science" (Crease 1997, p. 259). However, while positivism still exerts a significant influence on the philosophy of science, in the 1960s voices of dissent began to be heard. Among the earliest was that of Thomas Kuhn (1962), whose historical take on science flew in the face of science's claim to "objective truths" that transcend the vicissitudes of history. After Kuhn's opening initiative, positivist philosophy of science has been questioned in diverse quarters, including the sociology of science, social constructivism, and feminist philosophy. The present work may be located primarily within the challenge to mainstream philosophy of science that has been mounted by *phenomenology*.

As this book unfolds, the ideas and implications of phenomenological philosophy will be extensively explored. For immediate purposes, let us say the following. Positivist philosophy looks for meaning in formally determined relationships among fixed units of knowledge that have been objectively defined. In contrast, phenomenology sees meaning as arising from the hermeneutic (interpretive) interactions of participants in an evolving lifeworld, a dynamic context of lived experience. In an issue of the journal *Man and World* edited by philosopher Robert Crease (1997), the phenomenological-hermeneutic approach to the philosophy of science is laid out systematically. Featured here are the writings of Martin Eger, Eugene Gendlin, Patrick Heelan, Don Ihde, Theodore Kisiel, and Joseph Kockelmans. More recent contributions toward grounding science in phenomenological philosophy include *Models of the Self* (Gallagher and Shear, eds. 2000), *Heidegger's Philosophy of Science* (Glazebrook 2000), *Ideas for a Hermeneutic Phenomenology of the Natural Sciences* (Kockelmans 2002), *How Scientific Practices Matter* (Rouse 2003), *Philosophy of Technology* (Scharff and Dusek, eds. 2003), *Continental Philosophy of Science* (Gutting, ed. 2005), and *Science, Understanding, and Justice* (Eger 2006). Also noteworthy is *Hermeneutic Philosophy of Science, Van Gogh's Eyes, and God* (Babich, ed. 2004), a collection of essays honoring Patrick A. Heelan. Let me focus briefly on the work of Heelan, since it is especially relevant to what I am attempting in this book.

Although alternative approaches to the philosophy of science have met with particularly strong resistance in the philosophy of space, and of quantum mechanics (Uchii 1998), Heelan (1983) has pioneered the effort to open these fields to phenomenological investigation. According to Heelan, "a hermeneutical analysis…would go far to throw light on the basic 'mysteries' of the quantum theory" (1997). Following Heelan's lead, in the chapters to come I offer a unique phenomenological interpretation of quantum theory, quantum gravity, and cosmology — one that draws on the late writings of Martin Heidegger and Maurice Merleau-Ponty, and employs topological imagination in a reflexively intuitive way. At one point, Heelan remarks that "we do not ask of a philosophy that it contribute to the successful practice of science" (1997). In commenting thus, he appears to be implying a disjuncture between the work of philosophy and that of science. Yet is not science philosophy-laden in the sense that its practices are affected by the philosophical assumptions upon which it rests? Has not modern science assumed the Cartesian attitude presupposing the division of subject and object, and has this not strongly influenced the conduct of science, making detached "objectivity" the order of the day? I intend to demonstrate that, in the case of contemporary theoretical physics, scientific progress critically depends on shifting from the stance of Cartesian philosophy to a phenomenological posture that surpasses the subject-object split.

A notable difference between mainstream and phenomenological approaches to physics is that while the former is inclined to deny its philosophy-ladenness, the latter openly acknowledges it. This recognition of philosophical influence lends itself to the integration of philosophical, theoretical, and practical levels of scientific activity. In the phenomenological physics I will undertake, the doing of science and the doing of philosophy merge into a joint endeavor. This vitalizes the philosophy and makes it generative. Rather than merely explaining, analyzing, or critiquing extant physics from a detached vantage point, the philosophy now contributes something new to the physics that specifically addresses physics' own questions concerning space and time, matter and force. The fusion of science and philosophy embodied in the phenomenological physics I shall unfold leads to a *new* physics, with new solutions to long-standing problems that have proven intractable when approached in the conventional manner.

To prevent semantic confusion, let me point out that the term "phenomenological" is already widely used in physics, though with a meaning that differs markedly from the one given here. In his introduction to the phenomenological movement in philosophy, Herbert Spiegelberg (1982) identifies a variety of meanings associated with the word "phenomenological," several of these being "extra-philosophical" (see pp. 7–11). This is the sense in which the adjective "phenomenological" is commonly employed in contemporary physics. "'Phenomenological' laws are understood to be generalizations which simply *describe* regularities in physical events of various types, without regard to their *explanation* or derivation" (Willard n.d.). This descriptive way of doing physics normally involves less technical analysis and mathematical rigor than do formal approaches to the field. The phenomenological approach adopted in the present volume is also less technical and quantitatively exacting than is formal mathematical physics. But unlike the phenomenology widely practiced in physics today, the phenomenological physics of this book is an intuitive enterprise that takes as its point of departure the philosophical insights of thinkers like Merleau-Ponty and Heidegger.

The Self-Evolving Cosmos is intended for philosophically-oriented, interdisciplinary readers drawn to current developments in physics and cosmology. But it may not be enough to say that this work is interdisciplinary. "Transcultural" may be a better term, in the general sense of C. P. Snow's "two cultures." Snow (1959) commented on the regrettably deep division between the sciences and humanities, the latter including literature, art, and traditional philosophy. Doesn't the philosophy of *science* bridge the cultural divide? Mainstream philosophy of science clearly does not, since it has come down squarely on the side of the natural sciences. I venture to say that the approach to philosophy of science offered in this book — submitted in the spirit of Patrick Heelan and other "dissident" philosophers of science (see Chapter 11) — does contribute to spanning the cultural gap in that it exposes the "soft" phenomenological core of the "hardest" of the "hard" sciences, viz. physics. My hope is that readers will share my sense of the significance of the project to the extent of being willing to take up the transcultural challenge. Although the background and training of such readers may bring them to science from the outside, they will be disposed to extending themselves across the cultural chasm. By the same token, transcultural readers initially socialized *within* the language system of science will not be dismayed by the "foreign dialect" they may hear but will be inclined to listen in a new way.

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The opening chapter of the book situates the development of physics within the context of human development as a whole. Both are seen to involve the quest for unity and individuation. After examining in Chapter 2 the obstacle to unification under the prevailing orientation of contemporary physics, the phenomenological alternative is introduced in Chapter 3. Here we find that the very goal of physics shifts from a quest for static unity to the exploration of a dynamic unity-in-diversity. In Chapters 4 and 5, the *topological* nature of phenomenological physics is considered and a family of primary topodimensional structures is described. Far from being isolated physical objects, these wave-like dimensionalities are seen to constitute whole psychophysical lifeworlds. The next two chapters take up the *evolution* of lifeworld dimensions. In Chapter 6, I employ the idea of symmetry to articulate some essential principles of dimensional transformation and stages of dimensional development. Chapter 7 details the precise pattern by which dimensional vortices evolve in relation to one another. The principles of topodimensional development are applied to physics and cosmogony in the next three chapters. Chapter 8 features a phenomenological rendition of the extra-dimensional (Kaluza-Klein) approach to force-field unification. In Chapter 9, phenomenological intuition is specifically brought to bear on the question of how the universe evolves. The account of cosmic evolution is completed in the following chapter, where the generation of fundamental force fields and matter particles is worked out in detail via a cosmodimensional matrix. The book concludes with a chapter that highlights the *psychophysical* nature of cosmogony. Psychical aspects of all fundamental particles are identified and the reflexive character of phenomenological physics is explored.

The Self-Evolving Cosmos is the culmination of work dating back to the 1970s when I first applied intuitive topology to physics and other natural sciences. These efforts were carried forward in a series of essays later published as a collection under the title *Science, Paradox, and the Moebius Principle* (1994). One essay in particular paved the way for the present work. Titled "A Neo-Intuitive Proposal for Kaluza-Klein Unification," this paper is a preliminary attempt to address physics' problem of unified field theory via a phenomenological use of topology. Though problems in theoretical physics were subsequently examined in my *Dimensions of Apeiron* (2004), the question of unifying the forces of nature was not systematically engaged. In my more recent volume, *Topologies of the Flesh* (2006), topological phenomenology is advanced by working out the details of basic topodimensional processes and their co-evolution, but no attention is given here to issues in physics or cosmology. Building on these earlier initiatives, the present volume offers a full-blown phenomenological rendering of nature's unity-in-diversity in our self-evolving cosmos.

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Chapter 1
Introduction
Individuation and the Quest for Unity

The quest for unity in science may be traced to the oldest, most basic of human drives: that toward *individuality*. To be "in-dividual" is to be undivided, to possess a unitary core, a coherent and stable center of identity. From its inception, human development is guided by the tendency toward individuation.

In Sigmund Freud's approach, the emergence of internal unity is reflected in the infant's "primary narcissism" (1914), the diffusely cohesive image of its own body that constitutes the earliest manifestation of the ego. The dialectical nature of the individuation process is brought out in Lacan's (1953) elaboration on Freud. Lacan suggests that the first tentative appearance of an invariant body image occurs in the "mirror stage." Here the child begins to develop a stable sense of its identity, to form an image of its own body as a whole, when the mother's body can be mirrored back to it as its primary object or alter-ego. This possibility initially arises at around six months of age and depends, in turn, on the psychological separation of the infantile body from that of the mother. Developmental theorist Elizabeth Grosz (1994), in drawing on Lacan, thus observes that it is in the mirror stage that "the division between subject and object (even the subject's capacity to take itself as an object) becomes possible for the first time" (p. 32). From the very outset then, one's sense of oneself as an autonomous being is linked to one's experience of the other.

In examining the original condition for the emergence of individuality, Grosz brings in the role played by *space*:

> For the subject to take up a position as a subject, it must be able to be situated in the space occupied by its body. This anchoring of subjec-

> tivity in its body is the condition of coherent identity, and, moreover, the condition under which the subject *has a perspective* on the world, and becomes a source for vision, a point from which vision emanates and to which light is focused. (p. 47)

The emergent subject is "the focal point organizing space. The representation of space is...a correlate of one's ability to locate oneself as the point of reference of space: the space represented is a complement of the kind of subject who occupies it" (p. 47). Historically, the space in question, when fully developed, is "the perspectival space that has dominated perception at least since the Renaissance" (p. 48). In sum: "A stabilized body image, ...a consistent and abiding sense of self and bodily boundaries, requires and entails understanding one's position vis-à-vis others, one's place at the apex or organizing point in the perception of space" (p. 48). So, according to Grosz, the self takes form both in relation to others and to space.

Grosz cites Lacan's observation that, in the mirror stage, "'the total form of the body by which the subject anticipates in a mirage the maturation of his powers is given to him only as a *Gestalt*'" (1994, p. 42). Her conclusion is that the "mirror image provides an anticipatory ideal of unity to which the ego will always aspire" (p. 42). Although this "model of bodily integrity" is something "the subject's experience can never confirm," although "the stability of the unified body image...is always precarious" (p. 43), just this imagined unity of the ego or subject is the

> precondition...for all symbolic interactions and for an objective or scientific (i.e., measurable, quantifiable) form of space. The virtual duplication of the subject's body, the creation of a symmetry measured from the mirror plane, is necessary for these more sophisticated, abstract, and derivative notions of spatiality. (Grosz 1994, p. 45)

With these words, Grosz intimates a link between science's long quest for unity (symmetry, invariance, continuity) and the even longer search for unity that underlies the whole course of human development.

The connection actually was established years earlier by physicist David Bohm (1965) in his detailed study of the relationship between the notion of invariance in science and the perceptual development of the child. Bohm demonstrated that the kind of activity in which physicists engage when they relate their initially variable empirical observations to invariant mathematical forms can be traced all the way back to the way in which the child's perceptual world crystallizes from the inchoate flux of infancy. Just as the child comes to recognize, for example, that an object momentarily hidden from view is the *same* object when it reappears, the physicist — operating at a vastly greater level of abstraction to be sure — recognizes that certain relationships between physical variables (force and mass, energy and frequency, etc.) remain invariant with changes in space-time coordinates. According to Bohm, the latter is the ultimate extension of the former.

It should be clear that achieving object constancy — whether we are speaking of objects perceived by the child or objects studied mathematically by the physicist — is dialectically coupled with gaining *subject* constancy. On the one hand, because one's imagined body serves as the frame of reference from which all observations are made, an object seen to change with changes in viewpoint or perspective can be taken as the same object only insofar as the observer's body is implicitly sensed as remaining the same. But the subject could not attain coherence and internal stability in the first place if the original chaos of nature did not already lend itself to being ordered. If a core identity is to take shape, if a cohesive individual is to come into being, "Mother Nature" cannot be entirely erratic; she must be able to mirror back to the subject a modicum of regularity and lawfulness. There can be a stable self "in here" only in relation to a world "out there" that offers some measure of consistent patterning. For the objects encountered in the natural environment to be susceptible to being ordered, the environment must place some constraints upon them. The milieu must be bounded or closed in such a way that the objects can properly be contained. Without placing such a limitation upon the objects, their initially unbounded flux could not become channeled into regular patterns. Functioning in this limitative capacity, the environment assumes the character of *space*.

In Grosz's analysis of the individuation process, three principal terms can indeed be identified: subject, object, and space. This tripartite determination has a distinguished history. We can say, in fact, that, in its idealized form, it constitutes the basis of Western philosophy.

*

In the *Timaeus*, Plato states that “we must make a threefold distinction and think of that which becomes, that in which it becomes, and the model which it resembles” (1965, p. 69). The first term refers to any particular object that is discernible through the senses. The “model” for the transitory object is the “eternal object,” i.e., the changeless form or archetype. This perfect form is *eidos*, a rational idea or ordering principle in the mind of the Demiurge. Using his archetypal thoughts as his blueprints, the Divine Creator or transcendent subject fashions an orderly world of particular objects and events. As for “that *in* which [an object] becomes,” Plato speaks of the “receptacle,” describing the latter as “invisible and formless, all-embracing” (1965, p. 70). It is the vessel used by the Demiurge to *contain* the changing forms without itself changing (1965, p. 69). Plato goes on to characterize the receptacle as *space* (1965, pp. 71–72). The Platonic notion of space constituted the seed for a concept that was to come to fruition and play a critical role in post-Renaissance science and mathematics.

Plato’s receptacle actually was not entirely changeless. At times it tended toward inhomogeneity, being given to “irrational motion...fleeting potencies and constantly changing tensions” (Graves 1971, p. 71) that made it susceptible to “springing a leak.” That is, Platonic space was prone to being ruptured, to losing its continuity. In the course of the next millennium, however, the concept of space evolved. By the time of Descartes, the notion of space had matured into that of a completely homogeneous continuum. Descartes related his continuum to the idea of *extension*.

Consider, as an illustration, the simplified space represented by a line segment. In the Cartesian approach, it is intuitively self-evident that the line, however short, has extension. It must then be continuous: it can possess no holes or gaps in it, since, if the point-elements composing it were not densely packed, we would not have a line at all but only a collection of extensionless points. The quality of being extended implies the infinite density of the constituent point-elements.

Yet, at the same time, intuitive reflection discloses the paradox that the absence of gaps in the continuum not only holds this classical space together but also permits it to be *indefinitely divided*. Without a gap in the line to interrupt the process, there is no obstacle to the endless partitioning of it into smaller and smaller segments. As a consequence, though the points constituting this continuum indeed are densely packed, they are distinctly set apart from one another. However closely positioned any two points may be, a differentiating boundary permitting further division of the line always exists. As philosopher Milič Čapek put it in his critique of the classical notion of space, "no matter how minute a spatial interval may be, it must always be an *interval* separating two points, each of which is *external* to the other" (1961, p. 19).

The infinite divisibility of the extensive continuum also implies that its constituent elements themselves are unextended. Consequently, the point-elements of the line can have no internal properties, no structure of their own. An element can have no boundary that would separate an interior region of it from what would lie on the outside; *all* must be "on the outside," as it were. In other words, the Cartesian line consists, not of internally substantial, concretely bounded entities, but only of abstract boundedness as such (Rosen 1994, p. 92). Sheer externality alone holds sway — what Heidegger called the "'outside-of-one-another' of the multiplicity of points" (1927/1962, p. 481). Moreover, whereas the point-elements of classical space are utterly unextended, when space is taken as a whole, its extension is unlimited, infinite. Although I have used a finite line segment for illustrative purposes, the line, considered as a dimension unto itself, actually would not be bounded in this way. Rather than its extension being terminated after reaching some arbitrary point, in principle, the line would continue indefinitely. This means that the sheer boundedness of the line is evidenced not only locally in respect to the infinitude of boundaries present within its smallest segment; we see it also in the line as a whole inasmuch as its infinite boundedness would be infinitely extended. Of course, this understanding of space is not limited to the line. Classically conceived, a space of any dimension is an infinitely bounded, infinitely extended continuum.

On the classical view, it would be a category mistake to interpret the infinitude of space as a characteristic of what is *object*. Space is not an object but is the "receptacle" of the objects, the changeless context within which objects are manifested. This distinction, initially made by Plato, is reflected in the thinking of Kant, who held that perceptions of particular objects and events are contingent, always given to variation, but that perceptual awareness is organized in terms of an immutable intuition of space. In the words of Fuller and McMurrin, Kant took the position that "no matter what our sense-experience was like, it would necessarily be smeared over *space* and drawn out in *time*[1]" (1957, Part 2, p. 220). Implied here is the categorial separation of *what* we observe — the circumscribed objects — from the *medium* through which we make our observations. We observe objects *by means of* space; we do not observe space. It is within the infinite boundedness of space that particular boundaries are formed, boundaries that enclose what is concrete and substantial. The concreteness of what appears within boundaries is the particularity of the object. In short, an object most essentially is that which is bound*ed*, whereas space is the contextual bounded*ness* that enables the finite object to appear.

The spatial context is what mediates between object and *subject*. The latter (personified by the Demiurge in Plato's *Timaeus*) is the third term of the classical account and corresponds to what is *un*bounded. That an object possesses boundaries speaks to Descartes's characterization of it as *res extensa*, "an extended thing": what has extension will be bounded. In contrast, the subject is *res cogitans*, a "thinking thing." Entirely without extension in space, the subject has no boundaries or parts. As a consequence, it is indivisible. This is etymologically equivalent to stating that the subject is an *individual*. It is before this unbounded subjectivity that bounded objects are cast (the word "object" comes from the Latin, *objicere*, "to cast before"). The crux of classical cognition then, is *object-in-space-before-subject*. The object is *what* is experienced, the subject is the transcendent perspective *from* which the experience is had, and space is the medium *through* which the experience occurs. The relationship among these three terms is that of categorial separation.

Now, classically understood, the tripartite categorial division does not arise empirically; rather, it is taken as existing *a priori*, as always already given. However, even though the trichotomy is regarded as an ontological imperative present from the first, classical thinking can grant that one's *knowledge* of the absolute threefold division does require time to develop. The classical viewpoint therefore can allow that the subject's initial awareness of its individuality is associated with its sense of being "situated in the space occupied by its body" (Grosz 1994, p. 47). It is just that, on the classical view, this identification of subjectivity with embodiment in space merely reflects the subject's immaturity, its ignorance of its true transcendental condition. Yet if the subject, at bottom, is in fact perfectly indivisible thus transcendent of space, and if its objects are completely divisible thus immanent to space, could there be any genuine *interaction* between subject and object? This is of course but another way of stating the old *mind-body problem* that was never quite put to rest in the classical tradition: If mind and body are ontologically divided, how is it possible for them to interact? Assuming that some kind of interaction is undeniable, we appear led to the conclusion that Descartes's emphatic division of mind and body is in fact an idealization that overlooks the reality. While interaction does pose a difficulty for the dualistic species of classical thought, in monistic idealism the problem would appear to be obviated. Here the claim is made that, since only mind is real, since the body is naught but an illusion, in the final analysis mind-body interaction must be illusory. What idealism has never been able satisfactorily to explain, however, is why such an "illusion" would arise in the first place. In lieu of an explanation, we often are advised to accept the ultimate "mystery of it all." Note, moreover, that, if we look beneath the explicit content of what is asserted to its underlying form, we can see that "monistic" idealism is actually another form of *dualism*. Behind the assertion that body "is not real" is the subtler fact of syntax that body "*is*"; negated in overt content, the body is posited in underlying form; the covert effect of such a statement is to *maintain* the body. Mind is posited in the same basic way: "it is real." So, while the content of idealism discounts the body as "mere illusion" and affirms the mind as "real," the *form* of the classical statement, by positing body and mind in stark opposition to one another (one in simple negation, the other in simple affirmation), effectively renders them categorially distinct. In this failed denial of the body's reality, circumvention of the problem of interaction also fails.

From the dialectical standpoint, mind and body — or subject, object, and space — are not taken as pre-existent, fixed, and mutually exclusive categories. Rather, they are seen to develop in intimate relationship to one another. In fact, the dialectical approach that I propose enables us to see how classical thinking itself develops.

On this account, initially there is neither mind nor body, neither subject nor object nor space in any well-differentiated form — only an inchoate flux of embryonic possibilities. In the earliest fragment of Western philosophy, Anaximander referred to this undifferentiated condition as the *apeiron* (see Rosen 2004). Literally meaning "without measure," the old Greek word was variously interpreted as "limitless," "boundless," "indeterminate," or "unintelligible" (Angeles 1981, p. 14). In the proto-scientific discipline of alchemy, the incipient state of affairs was termed *prime matter*: "prima materia, which is the original chaos and the sea" (Jung 1970, p. 9). From the primordial flux, a subject-object mirroring process ensues. That is, quasi-stable objects are differentiated from the chaotic background in relation to an emergent subject before whom the objects are cast. As indicated above, object and subject constancies mirror each other in mutual feedback, thereby enhancing each other. Object and subject thus emerge together from the ever-changing background turbulence and a modicum of unity or invariance arises in them. At the outset, the stability that is realized is highly tentative and the nascent transactions between subject and object are utterly nonlinear. The unity achieved for the object clearly cannot be said to *cause* the subject to be unified, nor is influence transmitted in the other direction, from subject to object. In their still immature, largely undifferentiated relationship, subject and object achieve their unity ensemble, joined inseparably in a recursive mirror play wherein the flow of influence is wholly reversible and cannot be dichotomously parsed. As the differentiation of subject and object advances however, the initial lack of orientation is superseded and an asymmetry sets in. Eventually the action appears to flow in but a single direction: *from* subject *to* object. The subject, functioning as the seemingly exclusive source of agency, divides the object for the purpose of identifying within it a unity (stability, invariance, etc.) that will further enhance the subject's own unity. At this stage of development, the distinctions arising from the dialectical process have hardened into categorial divisions that are now assumed to have existed from the first. Only by virtue of the problem of interaction does the dialectic make its ghostlike presence felt: there is the haunting question of how the subject could exert any influence at all over an object from which it is categorically split. But this does not stop the subject from proceeding with its program of dividing the object so as to bring unity to itself.

In science, the subject proceeds by *analysis*, a word of Greek origin that means a "dissolving, a resolution of whole into parts; *ana*, up, back, and *lysis*, a loosing, from *lyein*, to loose."[2] Or we may say equivalently that "analysis" connotes "a breaking up."[3] The *modus operandi* of science then is to break things up, or — to use the more common manner of speech — it breaks things down. In fact, the process actually entails a *threefold* breakdown or division, since the object to be dissected must first be extracted from its context, and since the analyst him- or herself must assume a detached stance. In the humanistic program of classical science, the more effectively objects can be parted, the better they can be controlled, manipulated, and shaped so as to solidify the unity or integrity of the subject. By dividing the object into its parts, knowledge is gained of how the parts work together in the whole, and this clarification of the functioning of the object as an invariant whole contributes to the wholeness of the subject. Thus, whatever the purpose of the particular research, scientific analysis essentially involves a process of division that distills nature's variability into invariant features in the interest of securing the *analyst's* invariance (unity, stability, constancy, etc.). To be sure, the latter does not just refer to the unity of an individual person. In the work of science, personal needs have been sublimated into broader concerns about the welfare of humankind.

The scientific enterprise is well exemplified by the perennial search for the "basic building blocks" of nature. The object is to be analyzed into smaller and smaller components, dissected until we no longer can do so. At this point we will have "hit bedrock," arrived at the fundamental constituents of the object, the atoms that compose it. The Greek word "atom" is functionally equivalent to the word "individual": both mean "not divisible." What is indivisible is immutable, not susceptible to change. Reaching the atomic substrate of nature thus would mean reaching the point where all of nature's variability will have been eliminated. Nature would now be fully controllable. If the object could be manipulated at the atomic level, that of the ultimate "individual," the individuality of the subject would gain its ultimate reinforcement.

In sum, from the child's first tentative steps toward individuation to the sophisticated initiatives of science, the human enterprise has come to be governed implicitly by a fundamental formula: *object-in-space-before-subject*. The prime directive here is that objects be divided so as to secure and enhance the indivisibility of the subject, a task that is to be accomplished by situating the object within the infinite divisibility that is space. In the pages to follow we will see that — despite all the revolutions that have transformed physics over the past century, the underlying approach has not changed. But we are going to discover that however effectively this way of achieving unity has worked in the past, when it comes to the *ultimate* unification of physics, no longer is that the case. To complete the project of realizing a unified field theory, gravitational and quantum mechanical forces are to be accounted for in an integrated manner. Why has this task proven so difficult? What is it about quantum gravity that makes it so resistant to treatment under the old formula? Unification of the forces in question necessitates operating at an exceedingly minute level of nature. It is at this subatomic level that the analytic subject had hoped to be able to gain complete control over nature's objectivity. Yet we are going to find that it is precisely at this level that the classical problem of *subject-object interaction* — which had been ignorable at larger scales — now no longer can be. Thus we shall see that addressing the ultimate problem of theoretical physics requires that, at the same time, we come to grips with an ultimate *philosophical* problem. In this book, I intend to demonstrate that a radically new, thoroughly dialectical approach is needed to meet the challenge, one that surpasses classical philosophy's threefold division of object, subject, and space in recognition of their intimate entwinement and transpermeation.

Notes

1. I will explicitly address the role of time in due course.

2. *Webster's New Twentieth Century Dictionary*, 2nd ed., s.v. "analysis."

3. *The American College Dictionary*, 1968 ed., s.v. "analysis."

Chapter 2
The Obstacle to Unification in Modern Physics

2.1 Introduction

In the last chapter we found that science's goal of internal unity is advanced by achieving analytic control over the external world. When an object of nature is initially encountered, it will appear to the scientific observer as a more or less undifferentiated whole that is subject to unspecified variations. In analysis, the object under scrutiny is differentiated, broken down into its constituent parts enabling the analyst to understand precisely how these parts operate in the functioning of the whole. Brought into focus in this way, the object is stabilized, its initially undetermined variability now being eliminated or accounted for so as to allow invariant expression of its orderly patterns of action. By thus obtaining knowledge of the object's inner workings, the analyst is better able to predict its behavior and gain control over it. Needless to say, it is not only *particular* objects that are analyzed in science so as to render them invariant but also, classes of objects and their interrelationships. Thus Newton's analysis of the famous falling apple did not give him insight into the motion of that particular object alone, but into the invariant law of gravitational attraction governing the behavior of bodies throughout the universe. (It may seem at first glance that the notion of an "invariant object" entails a category mistake. For, in the classical formula, viz. object-in-space-before-subject, is it not the *subject* that is regarded changeless, whereas the object is susceptible to variation? We must realize however, that, on the classical view, the invariance of the object derives from the ordering activities of the subject, rather than from the object *per se*.)

Until the nineteenth century, the prime exemplar of unity in physics was Newton's universal theory of gravitation. Then, with the work of pioneers such as Oersted, Faraday, and Maxwell, another major unification was achieved. Magnetism and electricity were found to be closely related aspects of the same underlying force of nature. However, in the last two decades of the nineteenth century Maxwell's formulation of electromagnetism was challenged by the experiments of Michelson and Morley. This research raised doubts about the ether field that Maxwell had assumed to be the medium for the propagation of electromagnetic energy. The motionless "ethereal sea" was to serve as the absolute frame of reference for gauging the movements of electromagnetic waves within it. Since the notion of the ether field was the principal embodiment of the idea of classical space, the failure to confirm the former led to questions about the latter that soon precipitated a revolution in physics. While Maxwell's equations could not be shown to be invariant with respect to the classical dimensions of space and time, Einstein demonstrated that their invariance could be established within a new and integrated framework of space-time. In the special theory of relativity, the equations for electromagnetic interaction remain invariant under global (Lorentzian) transformations of four-dimensional space-time coordinates. Special relativity thus accounts for electromagnetic dynamics by allowing the old space and time to vary (to contract and become dilated, respectively) within a new, more abstract context of changeless space-time.

Now, the special theory of relativity was limited to the interaction of systems that are in uniform motion with respect to each other. Ten years after the 1905 appearance of this theory, Einstein unveiled his general theory. By switching from Minkowski flat space to the far more general Riemannian manifold, Einstein could now explain the interaction of systems in non-uniform relative motion. A crucial feature of general relativity was its demonstration of the equivalence of accelerated motion with gravitational effects. This qualified it as a theory of gravitation surpassing Newton's, which was now subsumed as a special case. Mathematically, the relativistic equations for gravitational interaction are invariant under local (Riemannian) transformations of space-time coordinates. What Einstein's general theory could not do was effectively specify a single invariance group containing electromagnetic and gravitational invariances as sub-groups. That is, the theory stopped short of unifying electromagnetic and gravitational forces. Theodor Kaluza (1921) attempted to address this limitation by suggesting that electromagnetism might be expressed in terms of a fifth dimension added to the four dimensions (three space-like, one time-like) that constitute the known universe in Einstein's theory of gravitation. But sixty years were to pass before the extra-dimensional approach to unifying the force field was to receive serious and sustained attention. The delay was occasioned by the need for progress to be completed in an area of modern physics equally as revolutionary as Einsteinian relativity.

At the close of the nineteenth century, just around the time when physicists were digesting the Michelson-Morley findings, another groundbreaking experiment on electromagnetism was being conducted. Max Planck was investigating blackbody radiation, the emission of electromagnetic energy in a completely absorbent medium, a closed cavity that does not reflect light but soaks it up, then discharges the energy internally. Classical theory faced a difficulty here that was on a par with the problem produced by the Michelson-Morley experiment. If the traditional analysis was correct, energy should be transmitted in a smooth and continuous fashion. Yet this assumption leads to the peculiar prediction that, if a nonreflective body is exposed to intense heat, it should radiate an *infinite amount* of energy — a result that clearly is not borne out by empirical observation. Planck responded to the contradiction by boldly amending the underlying classical assumption. He proposed that light, rather than radiating in a smoothly continuous manner, is transmitted in discrete bundles, *quanta*. The introduction of discontinuity into the theory now brought a remarkable correspondence with empirical data. The new quantum theory could predict laboratory findings to a high degree of accuracy by adding just one parameter, h. This is the constant of proportionality that relates the energy (E) of a quantum of radiation to the frequency (v) of the oscillation that produced it: $E = hv$. The numerical value of h is 6.63×10^{-34} joule-seconds. The extremely small value of Planck's constant is consistent with the fact that, in the familiar world of large scale happenings, energy does appear to propagate in a smoothly continuous fashion. It is only when we "look more closely," examining the microscopic properties of light, that we notice its discontinuous, quantized grain.

By the mid-1920s, the quantum mechanical approach to physics had come to the fore and the problem of unifying the forces of nature was presently defined in terms of the quest for a quantum theory that included gravitation. In this context, Oscar Klein (1926) showed that it is possible to write Schroedinger's wave equation in five independent coordinates, thereby demonstrating the basic compatibility of Kaluza's earlier proposal with quantum mechanics. Regarding the question of how the fifth dimension needed to account for electromagnetism could be accommodated in a universe apparently limited to only four dimensions, Klein supposed that the additional dimension could be compactly curved or compressed, hidden at the ultra-microscopic scale of 10^{-35} meter. What is the significance of that tiny magnitude? It is the length set by Planck below which the observable universe goes completely "out of focus," yielding to an all-pervasive uncertainty. In the original Kaluza-Klein account, the unobservable fifth dimension was assumed to be concealed by the spatiotemporal uncertainty associated with the Planck length.

In the years following the extra-dimensional conjectures of Kaluza and Klein, technological advances permitted the construction of particle accelerators enabling the study of two new fundamental forces: the strong force by which atomic nuclei retain their cohesiveness, and the weak force, which mediates radioactive nuclear decay. At the subatomic scale on which these forces operate, gravitation — the weakest of the forces — plays a negligible role. Therefore, in devising abstract gauge theories to unify subatomic forces (including electromagnetism) as members of the same internal symmetry group, physicists could largely disregard the exterior dimensions of space and time more directly relevant in the context of general relativity. During this phase of the quest for unification, development of a Kaluza-Klein theory was not a high priority. But by the late 1970s, weak and electromagnetic forces successfully had been unified by Weinberg and Salam, and an effective theory of the strong interactions formulated (quantum chromodynamics); moreover, the prospects seemed good for a grand unification encompassing all three forces. Now the deferred question of quantum gravity reasserted itself, and this revived interest in a Kaluza-Klein program (Scherk and Schwarz 1975; Cremmer and Scherk 1976). The approach to quantum gravity that is currently attracting the most attention is *string theory* (pioneered in the late 1960s and 1970s by Gabriele Veneziano, John Schwarz, Joël Scherk, Michael Green, and others). Here the four forces of nature are expressed in terms of several basic Planck-scaled force particles which are assumed to be string-like in character and which require ten dimensions for their unification (in the newest version of string theory, known as *M-theory*, eleven dimensions are actually entailed, though the eleventh dimension is not like the other ten; see Chapter 8).

We shall now proceed to explore at a fundamental level the conceptual implications of the recent quest for unity in physics. As we progress, it will become clear that unification cannot adequately be addressed merely as a theoretical problem, that the *philosophical* questions broached in Chapter 1 need to be confronted in any full and effective treatment of the matter.

In the introductory chapter, I adumbrated the way in which the division of subject, object, and space arose from an underlying dialectical relationship in which the three ontological modalities were in fact inseparably intertwined. I ended the chapter by intimating that the riddle of quantum gravity can be solved only through an approach that pays heed to the dialectic. In the following chapters, a dialectical alternative will be spelled out at length. What I intend to demonstrate in the present chapter is that, while modern unification theory indeed may appear to move toward a dialectical way of thinking by seeming to call into question the classical formula of object-in-space-before-subject, in actuality the old formula has been implicitly maintained and this in effect has precluded unification.

2.2 Does Contemporary Mathematical Physics Actually Depart from the Classical Formulation?

2.2.1 Apparent concretization of mathematical physics via symmetry breaking

The notion of invariance that we have discussed is intimately related to the idea of symmetry. A primary strategy of contemporary theoretical physics is to describe the laws of nature in terms of mathematical symmetry. In general, a symmetry is defined when some characteristic of a body or system remains the same despite the fact that a change has been introduced. For example, if a sphere is transformed by rotating it through any angle about its center, its appearance will not change. The sphere therefore can be said to be symmetric under the operation of rotation. This simple notion of symmetry is generalized in group theory, where a variety of mathematical systems can be classified in terms of the groups of transformation under which they remain invariant. Applying the approach to theoretical physics, the laws of physical interaction are described by means of abstract symmetries. Thus, in the framework of special relativity, electromagnetic interaction is said to be symmetric under global transformations of space-time coordinates, and, in general relativity, gravitational interaction is symmetric or invariant under local transformations of coordinates (as noted above). The technique has been especially emphasized in quantum field theory, where invariance in the form of physical interactions among subatomic particles has been studied under transformations of particle properties such as electric charge or strong nuclear charge ("color"). (Note that, whereas the space-time transformations of relativity theory still bear some concrete relationship to the framework within which ordinary human observation occurs, the "interior space" of quantum field theory is purely a mathematical abstraction.)

Now, if the laws of physics can be expressed in terms of abstract symmetry relations, would it not be possible to define more general symmetry groups under which two or more kinds of physical interactions could be subsumed as subgroups? Such an extended application of the idea of symmetry constitutes the basic rationale for unification. The initial contemporary example was mentioned above: the electroweak unification achieved independently by Weinberg and Salam in 1967–68. At first glance, this accomplishment actually may seem to introduce the potential for a fundamental change in philosophical orientation. The Weinberg-Salam breakthrough may appear to cast doubt on the purity of theoretical physics. Let us see why this is so.

Understood most essentially, the "purity" of physics depends on maintaining the threefold categorial division previously discussed — that among object, subject, and space. To reiterate, the object is *what* is experienced, the subject is the detached perspective *from* which the experience is had, and space is the medium *through* which the experience occurs. The classical categories may also be distinguished in terms of the unidirectional flow of influence we have examined. With the subject taken as the primary source of agency, action spreads irreversibly from it to its object, the effect being mediated by the space in which the subject carries out its operations. The subject, regarded classically as in(di)visible, is essentially a *deus ex machina*; it is the unseen, unmoved mover (cf. Aristotle) of (di)visible objects. We have learned that the initially undifferentiated object is divided by the subject for the underlying purpose of bringing unity and order to the chaotic diversity of nature; in this way, the subject brings unity to itself, realizes its potential, gains cognizance of the individuality that, at bottom, it has in fact always possessed. On the classical account, the object alone is transitory, mutable, given to change; both the subject and the spatial "receptacle" through which it operates are taken as inherently changeless.

The symmetries of mathematical physics express most basically the unity the subject has brought to nature's initial variability. To understand the exact role of symmetry in the trichotomous classical formulation, we may take as a model a graphed equation. Consider the simple example of the equation for a parabola, $y = x^2$.

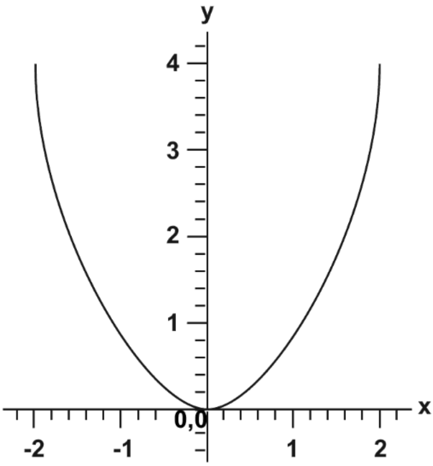

Figure 2.1. Graph of $y = x^2$, the equation for a parabola

In the graph of the equation (Fig. 2.1), x and y are variables, terms whose specific values change from point to point in xy coordinate space. What does not change is the *relationship* between these variables as given by the equation. Since the equation expresses what remains invariant when particular values in the coordinate system are transformed, it can be said to constitute a symmetry. It is clear that the invariance of the equation depends on the continuity of the functional space in which the relationship between variables is graphed. Were there a breach in the continuum, at this singular point the relationship would be abrogated and the equation would assume a nonfinite value. We can see from this that the symmetry of the mathematical object (the equation) requires the symmetry of the space in which the object is contained. Whatever transformations of variables may occur within the spatial container, for the *relationships* between variables in the objects under study to be rendered invariant, the container itself must be invariant; it must stay intact, retain its continuity. Bear in mind that, on classical thinking, there is a *categorial* distinction between these two kinds of symmetry. Whereas object symmetry is linked to empirical observations of variables, the symmetry of space per se is *epistemological*. The way this was stated in Chapter 1, space is not an object to be known but is the *means by which* the subject does the knowing.

The subject itself can also be located in the graph of the equation, at least indirectly. At the center of the xy coordinate system is the 0,0 origin. The origin of the function space plays a unique role. Representing the locus at which observation begins, 0,0 serves, in effect, as the surrogate for the subject's "eyes," the point of view from which its empirical observations are made (see Rosen 2004, Chapter 1). So the three terms of the classical formula are well discernable in Figure 2.1. The graphed mathematical relationship between variables is associated with the object category; the xy coordinate system is the space in which the object is studied; and the 0,0 origin of the graph is the subject's point of perspective on that object. In this scheme, the object symmetry or invariant equation mediates between the variability of the particular object and the invariance of the subject and its space.

On the classical view, the equations giving the laws of nature are not themselves empirical objects but more like Plato's "eternal objects" (see Chapter 1). That is, they are not facts of nature but normative principles that regulate nature; as such, the laws are not to be thought of as changing or developing. However, in the contemporary inquiry into the question of unification, emphasis shifts from concern about relating concretely observable differences to abstract uniformity, to concern about differences among the abstractions themselves. Although physical processes do not seem to lend themselves to being expressed in fewer than four distinct abstract forms, might there nevertheless be a way that these four symmetries could be rendered symmetric with respect to each other, reduced to a single symmetry? The answer proposed by Weinberg and Salam was that these symmetries *were* symmetric with respect to each other in an early phase of cosmogony, but that this all-embracing primordial symmetry subsequently was broken spontaneously. Does this suggestion, now widely accepted by theoretical physicists, imply a reversal of roles between empirical process and normative structure?

In the long-sanctioned approach of attempting to express dynamic occurrences in terms of abstract symmetries, theoretical physicists, in effect, were seeking to relegate concrete change to secondary status, render it an epiphenomenon of changeless structure. But the concept of spontaneous symmetry breaking required for unification weds physics to cosmogony, and, in consummating the marriage, doesn't cosmological time emerge as the measure of formal structure? Would this not amount to a concretization of symmetry relations that previously were regarded as pure abstractions, as normative principles for describing and ordering nature that were themselves outside of nature, exempt from its dynamics? Now it would no longer merely be the *contents* of nature that are viewed as changing in accordance with nature's invariant form; the form itself would be regarded as open to historical processes. Whereas, in classical thinking, said form serves the subject's aim of rendering nature invariant, the dynamization of the laws of nature seemingly implicit in symmetry breaking would call into question the hitherto fixed categorial division between variable empirical objects and the subject's invariant norms; in so doing, it would pave the way for a dialectical approach.

Ten years after the Weinberg-Salam electroweak unification, when the quest for quantum gravity became a pressing issue again, the apparent dynamization of the other hitherto static classical category became evident: in the context of revived Kaluza-Klein theory, space itself was seen to evolve in the course of cosmogony. We know that, in classical physics and philosophy, space and time are taken as the changeless framework within which changes in objects are observed and brought about (by the subject). As Kant saw it, the dimensionality of space and time, its immediately intuited 3+1 character, is no empirical fact but is given *a priori* as an article of pure reason, and thus not susceptible to alteration. These are the precepts that were challenged in the Kaluza-Klein elaboration on the Weinberg-Salam idea of spontaneous symmetry breaking.

According to the basic Kaluza-Klein interpretation of cosmogony, the primordial symmetry condition encompassing all four forms of physical interaction requires for its expression a compact, multi-dimensional manifold, with all dimensions being "real" ("regarded as true, physical dimensions"; Witten 1981, p. 412), and all coexisting at the same microscopic scale (close to the Planck length). The event of symmetry breaking is associated with what may be called "dimensional bifurcation": a subset of dimensions expanded relative to the remaining dimensions, and, in so doing, broke the initial equilibrium. The expanded, 3+1-dimensional universe known to us today — far from being given *a priori* as an article of pure reason — is the result of this cosmogonic process of dimensional transformation. Thus, the apparent consequence of the revitalized Kaluza-Klein approach is that spatiotemporal dimensionality is no longer regarded strictly as a changeless framework for change. Dimensionality itself is seemingly thrown into the arena of concrete change, thereby mitigating the absolute distinction that had been drawn between the spatial container and the dynamic processes it contains.

But has such a radical step actually been taken in Kaluza-Klein theory?

2.2.2 The implicit attempt to maintain the classical formula and its ultimate failure

Although contemporary Kaluza-Klein theory does render variable what previously had been taken as invariant, in its mathematical treatment of this, it actually hopes to stay faithful to the old tripartite formula. For instead of now giving primacy to dynamic process, the new variability described by Kaluza-Klein is to appear in a novel context of superordinate invariance. Yes, the laws of nature that earlier had seemed to be unchanging are presently viewed as evolving, along with their hitherto changeless dimensional framework. Yet the evolution is hardly expressed as a dialectical event posing a fundamental challenge to the fixity and separation of the old ontological categories. Instead the attempt is made to *objectify* the cosmogonic process by which symmetry is allegedly broken and spacetime transformed; erstwhile invariant laws and their dimensional framework are presently taken as variables in a new invariant equation set that is to be written for a higher-dimensional, intrinsically invariant space. Therefore, despite the vast difference in the appearance of the Newtonian universe and that of Kaluza-Klein, at bottom both are guided by the underlying principle of object-in-space-before-subject. It is true that the "objects" are now no longer concrete bodies in motion or fixed laws of nature, but laws of nature that evolve, along with their associated spatiotemporal dimensions. Still, this rather more abstract version of nature's objective variability is to be rendered invariant by a detached subject, one who is himself considerably more abstract than the Newtonian subject, and who seeks to operate in a changeless medium of greater dimensionality.

Kaluza-Klein theory is certainly not the first that appears on the surface to dynamize physics while implicitly seeking to preserve the old formula. Kaluza-Klein is an elaboration upon the original theory to adopt this basic strategy: Einsteinian relativity. We have seen that, with Einstein, classical space and time become variables within a new and more abstract four-dimensional framework of changeless space-time. In the Kaluza-Klein account, four-dimensional space-time itself becomes a variable in a still higher-dimensional invariant context.

In the simplified schema for the standard Kaluza-Klein formalism given in Figure 2.2, an initially "compact" two-dimensional space is depicted as expanding to observability along its horizontal axis, its vertical dimension remaining "microcosmically scaled." This differential expansion breaks the purported perfect symmetry of primordial space. By analogy, we may imagine a primordial manifold of ten dimensions (to use the string-theoretic interpretation of cosmogony) being transformed so as to produce our presently observable 3+1-dimensional universe. In this account, the evolving dimensions are of course *objectified*, cast within an analytical continuum or epistemological space that itself does not evolve.

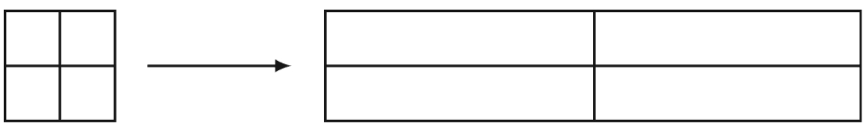

Figure 2.2. Schema for standard formulation of Kaluza-Klein cosmogony

In Kant's day, the categorial distinction between a concrete object and its spatial context was fairly clear-cut. Once again, the object is *what* is