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Articles

SIMONE WEIL'S SPIRITUAL CRITIQUE OF MODERN SCIENCE: AN HISTORICAL-CRITICAL ASSESSMENT

by Joseph K. Cosgrove

Abstract. Simone Weil is widely recognized today as one of the profound religious thinkers of the twentieth century. Yet while her interpretation of natural science is critical to Weil's overall understanding of religious faith, her writings on science have received little attention compared with her more overtly theological writings. The present essay, which builds on Vance Morgan's *Weaving the World: Simone Weil on Science, Necessity, and Love* (2005), critically examines Weil's interpretation of the history of science. Weil believed that mathematical science, for the ancient Pythagoreans a mystical expression of the love of God, had in the modern period degenerated into a kind of reification of method that confuses the means of representing nature with nature itself. Beginning with classical (Newtonian) science's representation of nature as a machine, and even more so with the subsequent assimilation of symbolic algebra as the principal language of mathematical physics, modern science according to Weil trades genuine insight into the order of the world for symbolic manipulation yielding mere predictive success and technological domination of nature. I show that Weil's expressed desire to revive a Pythagorean scientific approach, inspired by the "mysterious complicity" in nature between brute necessity and love, must be recast in view of the *intrinsically* symbolic character of modern mathematical science. I argue further that a genuinely mystical attitude toward nature is nascent within symbolic mathematical science itself.

Keywords: algebra; Albert Einstein; Jacob Klein; mysticism; physics; Pythagoreanism; science; spacetime; symbolic mathematics; technology; theory of relativity; Simone Weil; work

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In an entry from her Marseilles notebooks, Simone Weil remarks that "not much would be required (yet a lot in a certain sense) to bring us back from contemporary science to an equivalent of Greek science" (Weil 1956, 69). What would be required is a return to a mystically oriented science on the model of the ancient Pythagoreans. For such a science, mathematics in its "mysterious appropriateness" serves as a bridge, or *metaxu*, between God and humanity (p. 514).

Much would be required to reorient science in this way, because *metaxu* require of us a recognition of connections we are loath to make. "We hate the people who try to make us form the connections we do not want to form," Weil remarks in another notebook entry (p. 349), and this is as true of science and technology as of any other sphere of human life. A bridge between ourselves and God threatens us with the truth about what we are in relation to God, and to avoid this truth we make idols of the bridges themselves. This, according to Weil, is what modern science, especially twentieth-century science, has done.

Scholarship on Weil's philosophy of science has taken a significant step forward with the appearance of Vance Morgan's *Weaving the World: Simone Weil on Science, Mathematics, and Love* (2005).[1] Morgan's aim is essentially expository, however, and his work calls for a critical assessment of Weil's thought on science. The present essay is an initial attempt, from a perspective sympathetic with Weil, at such an assessment.

Weil's critique of modern science consists of two parts, the first directed at classical (Newtonian) science, the latter at contemporary science, especially twentieth-century relativity and quantum mechanics. In each, Weil detects a species of thoughtlessness or failure of that prayerful attention that marks all genuine study and intellectual accomplishment. As regards classical science, Weil's objection is specifically focused on the manner in which it undermines the human encounter with beauty through work. Classical science, by conceiving nature as merely a machine, to which human beings can relate only as slave or master, not as loving participants through work, is fundamentally incompatible with beauty as a revelation of divine love.

The assimilation of algebra by mathematical physics, a process spanning the eighteenth and extending into the nineteenth century, exacerbates the implicit thoughtlessness of classical science by subordinating scientific cognition to symbolic formulae increasingly devoid of insight. In the process, a genuine encounter with natural necessity, revelatory of divine providence, is lost to science. Symbolic or algebraic physics represents the collectivization of thought, as it were, where science itself is rendered a technique of knowledge production and thought ceases to be the activity of any responsible individual. "The number 2 thought of by one man," remarks Weil, "cannot be added to the number 2 thought of by another man so as to make up the number 4" (Weil 1958, 82). This process reaches its logical conclusion in twentieth-century physics, where science is reduced finally to a form of symbolic manipulation the only value of which is predictive success and technological domination of nature.

Although Weil's philosophy of science is in my view startlingly insightful, I believe she is at once too optimistic and too pessimistic about modern science: too optimistic because she underestimates how much would be required to reorient science toward the mystical, and too pessimistic in that she reproves modern science for sins of which it is not guilty, at least not in the way or to the degree she maintains. These twin shortcomings seem to stem from misreadings of the history of science on Weil's part. She evidently forecloses the possibility that the symbolic form of representation might be intrinsic to mathematical science, as opposed to a merely convenient shorthand for quantitative relationships that could, and ideally should, be conceived nonsymbolically.[2] This assumption renders her insufficiently sensitive to the intractability of the symbolic collectivization of thought in contemporary civilization. Moreover, to a significant degree she conflates twentieth-century physics itself, specifically relativity and quantum mechanics, and textbook versions designed to initiate prospective scientists in the mathematical techniques of the theories. In so doing she creates the erroneous impression that in these theories genuine thought has been virtually replaced by mathematical technique. This makes her unnecessarily pessimistic about the spiritual prospects for science.

My aim, however, is not to find fault with Weil's philosophy of science but rather to make a modest contribution to bringing it to bear upon our present situation. I believe that if we do not correct these misreadings of the history of science, we shall not be able to avail ourselves of Weil's profound reflections on the spiritual malaise of our increasingly scientifically and technologically driven civilization.

Science and Number Mysticism

Weil's philosophy of science takes its inspiration from Pythagorean number mysticism. Mysticism in general for Weil is defined by a kind of movement through contradiction or paradox that finally transcends, while not resolving, the opposition constituting the paradox. Only at the point where the intellect exhausts itself in the attempt to resolve contradiction has it reached the threshold to a mystical revelation of divine truth. A mystical relationship to the physical cosmos is specifically characterized by the opposition it embodies between the impersonal and the personal or intelligent. That is to say, the physical cosmos embodies the paradox of *necessity* or impersonal intelligence.

Weil evidently first encountered this notion of necessity in the Greek Stoics, who reinterpreted *moira*, or "fate," as divine providence. Necessity, a blind mechanism somehow infinitely more than blind, renders the cosmos beautiful, an object of love: "We are ruled by a double law," Weil observes, "an obvious indifference and a mysterious complicity, as regards the good, on the part of the matter which composes the world; it is because it reminds us of this double law that the spectacle of beauty pierces the heart" (1968, 12).

To grasp the truth of mathematics, we must bow to that impersonal necessity which defines relationships between numbers (there is "no 'I' in numbers," Weil remarks in one of her notebook entries [1956, 191]).[3] Yet at the same time the very absence of any arbitrariness in mathematics bespeaks a principle of intelligence, or *logos*. This paradox makes mathematics mysterious and beautiful—and it makes mathematical science a form of loving obedience to the divine *logos*.

From the perspective of Weil's analysis, it is no accident that we find among the great architects of seventeenth-century mechanics, a science founded under the banner of mastery of nature and the rational transparency of corporeal being, no number mystics.[4] Galileo, for instance, asserts that within the domain of mathematics, human understanding is equal to God (Galileo 1967, 103). Presumably mathematical necessity is no mystery to God. Descartes goes further, maintaining that the truths of mathematics are a product of divine fiat, seemingly necessary to us, but in themselves solely contingent upon the divine will (Descartes 1985–91, III: 23; letter to Mersenne of 15 April 1630). Descartes thus forecloses entirely the impersonal dimension of mathematical necessity and in so doing dissolves the mysteriousness of mathematics. In general, classical science based itself from the beginning on an idea of *method* as control of the cognitive encounter with nature according to the demands of the autonomous human intellect. Such an approach is deeply hostile to a mystical view, where the human knower is always in some way dependent upon the self-disclosure of the thing known.

The historical origins of modern science thus raise the question of whether a mystical reorientation of science of the kind Weil envisions is possible within the Western scientific tradition. It certainly cannot be simply assumed that it is, that we could somehow rid science of its spiritually disagreeable elements while retaining our electric lights, cell phones, and broadband Internet connections. If it is not possible, Weil is surely wrong to say that not much would be required to reorient science on the model of the Greeks.

Although there is little chance of my succeeding where Weil at least partially failed, some philosophical observations regarding the historical implications of her spiritual critique of science may be worthwhile.

Classical Science and Work

In her early treatment of classical science, the dissertation *Science and Perception in Descartes* (1987), Weil descries an essential connection between mathematical physics and work. Genuine knowledge of the world, she argues, as opposed to uncontrolled imaginings of it, requires that our intellect come into indirect contact with the material universe through our bodies, pressing on the world, as it were, and feeling it press back. Such a pressing on something that presses back is work, or physical labor. Work reaches its effect, however, only by conforming to geometry (a fact that receives a kind of general mathematical expression, one might say, in Newton's law of action/reaction[5]), for by working I make myself part of a machine, the successful operation of which is governed by geometrical principles (1987, 82). When I dig in the garden, for instance, I make myself part of a lever. Work, like the science of geometry, but also via the geometry of nature conceived as a machine, thus puts us in touch with necessity. Machines work only because nature is governed by mathematical necessity, a necessity I feel in the ache and fatigue of my muscles when I work.

In view of the primacy of physical work in focusing our attention, such that we attain to genuine perception of the world as opposed to a dream-like state fabricated by the imagination, what is the purpose of science, which seems by its very nature to break the connection between physical labor and perception of the world? Science is needed to master the imagination in the latter's propensity to run itself beyond that limited section of the world that can be perceived through individual work. That is to say, science is necessary, as Weil puts it, to teach us that when we are not working, the understanding of the world that we had when we were working is all there is (1987, 85–86). By this means science disciplines the imagination, focusing the attention in a manner analogous to physical labor.

Indeed, intellectual labor, on Weil's account, is of value solely through its analogy to physical labor, for in intellectual labor we come into contact *indirectly* (via mathematics, for instance) with that necessity with which we come into contact *directly* through physical labor. In whatever way Weil's understanding of the spiritual significance of physical labor changes in subsequent years—her recognition and first-hand experience of its potentially brutalizing side, for example—this remains constant: that contemplation of truth is essentially tied to physical labor, the kind that enters the body as fatigue or even pain. As Weil famously asserts in the final sentence of *The Need for Roots*, physical labor is the spiritual core of human life (1952, 288).[6]

We must therefore understand Weil's objections to classical science in terms of the specific metaphor of work the latter uses to understand nature. Classical mechanics conceives nature as a working machine. Weil rightly observes, for instance, that the concept of energy is entirely dependent upon the metaphor of work (1968, 6–8).[7] Yet, in this conception of work, one of the terms defining the paradox of necessity has fallen away. Classical mechanics conceives nature as *only* a blind, deterministic mechanism, whereas work involves effort, aspiration, hope, contingency. In this way, the metaphor of work in classical mechanics loses its basis in the nature of things. The situation is not at all altered by the "craftsman God" of seventeenth-century philosophy, skilled artificer whose universe runs itself like a well-designed watch. As Weil remarks, "There is no question, of course, of imagining any sort of wills at work behind the phenomena of nature because these would not be analogous to human wills. . . . they would be exempt from the conditions of work" (1968, 6). Thus the universe conceived as a working machine is not a spiritual laborer, as it were, but rather a slave, as Descartes intended when he said that his new science would make us the "masters and possessors of nature" (Descartes 1985–91, I:142–43). Moreover, the human laborer is himself rendered a slave, since matter as conceived by classical science is straightforwardly indifferent to our desires, hopes, and aspirations. That indifference is true enough, but the description becomes false by losing all correlation to its opposite, the providential necessity or divine *logos* of which the Stoics could with love sing, "Lead me, Destiny, and I will follow." In modern science, says Weil, there is simply nothing to love.

Classical science's attempt to dissolve the mystery of necessity by focusing exclusively on one of its poles (deterministic causality) at the expense of the other (love, or the transcendent *logos*) bears the mark of a kind of "reification of method," in which the means of representation is taken for the reality represented. Indeed, Weil's analysis is reminiscent of Edmund Husserl's in *The Crisis of the European Sciences:*

> Mathematics and mathematical science, as a garb of ideas, or the garb of symbols of the symbolic mathematical theories, encompasses everything which, for scientists and the educated generally, *represents* the life-world, *dresses it up* as "objectively actual and true" nature. It is through the garb of ideas that we take for true being what is actually a *method.* (Husserl 1970, 51)[8]

Weil remarks similarly,

> The process of calculation places the signs in relation to one another on the sheet of paper, without the objects so signified being in relation in the mind; with the result that the actual question of the significance of signs ends by no longer possessing any meaning. One thus finds oneself in the position of having solved a problem by a species of magic, without the mind having connected the data with the solution. Consequently, here again, as in the case of the automatic machine, method seems to have material objects as its sphere instead of mind; only, in this case, the material objects are not pieces of metal, but marks made on white paper. (Weil 1958, 94)

The ensuing adoption of algebra or symbolic mathematics as the exclusive language of modern mathematical physics thus will be, in Weil's view, the very example of that reification of method nascent in classical science from the beginning.

Science and Algebra

Weil associates the spiritual malaise of modern science with the advent of modern algebra in the sixteenth and seventeenth centuries and its assimilation into physics in the eighteenth and nineteenth centuries. Algebra, she maintains, substitutes technique for genuine insight into necessity. Blindly manipulating symbols increasingly devoid of any discernible physical meaning, science trades truth for mere predictive success and power. In classical science prior to the latter half of the nineteenth and especially the twentieth century, however, the algebraic formulae could still be correlated with imaginable physical mechanisms such that the connection between science and work was not entirely broken. But with relativity and quantum mechanics in the twentieth century, she believes, the connection has broken down completely.

To better appreciate Weil's objections to algebraic physics, consider the classical formula for kinetic energy: $E = mv^2/2$. No insight into the laws of nature is required to manipulate such a formula. One need only "plug in" the values of the variables m and v respectively and apply the rules of algebraic calculation. Moreover, there exists a *prima facie* incoherence in multiplying together the two heterogeneous quantities mass and velocity. How are we to "cash in,"[9] as it were, such a formula in the real world, the world in which we live our lives? For Weil, all such valid formulas should in principle be interpretable as proportions, subject to representation in the imagination, between intuitively evident physical quantities. Thus the equation $E = mv^2/2$ would be regarded as symbolic shorthand for an intuitive representation in terms of the amount of work (force acting through a distance) required to accelerate the body to velocity v. As long as a concrete insight of this kind into natural necessity is attained, there is no harm in employing the symbolic formula. Symbolic physics becomes spiritually destructive, however, when formulas begin to *replace* insight. For now the laws governing the physical universe can only appear arbitrary, with the beautiful Pythagorean and Stoic *cosmos* degenerating into a mere mathematico-empirical "system" unfit to bear witness to the divine *logos*.

Weil's analysis of the role of algebra in modern physics, however, is not entirely adequate.[10] Algebra in its modern incarnation is far more than simply a powerful technique that as such continually runs the risk of substituting blind manipulation of symbols for genuine insight. To be sure, this is one feature of algebra, but it is of secondary importance to modern science. Of primary importance, as the historical investigations of Jacob Klein demonstrate, is that algebra alters the very intelligibility of *number* by reconstituting number as an essentially symbolic entity.[11] In its modern algebraic conception, number is no longer merely an abstraction from experienced nature but rather a symbolic construction, itself a technological artifact if you will. For modern mathematics, that is to say (to appropriate in slightly altered form a quip attributed to the American logician W. V. Quine), to be a number is to be the possible value of an algebraic variable. Correspondingly, modern mathematical or algebraic physics reconstitutes nature itself as a symbolic entity. Indeed, *science* and *technology* in the sense we use those terms today are possible solely on the basis of this symbolic reinterpretation of nature.

As Klein points out, the Greek conception of number, regnant in the West until the late sixteenth century, was abstract but not symbolic. I can form an abstract idea of "3," for instance, via repeated encounters with three apples, three oranges, three people, three cars, and so forth. "3" means the apples, oranges, people, or cars. I cannot similarly abstract the idea of "–3," because there exist in nature no countable collections (or "multitudes of units," after Euclid) of "negative-three things" from which such an idea could be abstracted. "–3" rather designates a symbolic entity, "the number negative-three" itself. Only indirectly does it refer to anything in nature. And on the modern conception of number, this is just as true of "3" and all other numbers. In this way we can distinguish between an abstract and a symbolic conception of number. Irrational numbers, for instance, are possible only as symbolic entities.[12] The Greek conception of number, by contrast, is determined by an abstract but essentially natural intelligibility. That is true even of the so-called algebraic mathematics of Diophantus, which employs symbolic variables (Klein 1968, 126–49). These variables always designate merely unknown collections of countable units, never symbolically conceived numbers.

The use of symbolic algebra in physics would therefore appear problematic *prima facie*, because the science of physics claims to be "about" the physical world itself rather than about a symbolic entity. Indeed, for a century or so after Newton, mathematical physicists resisted the use of algebra, none more so perhaps than Newton himself, and for the very reason of the felt need to keep symbolic and physical quantities conceptually distinct. Mathematical physics instead employed the traditional language of ratio and proportion. At some point in the nineteenth century, the equations of physics generally ceased to be understood as abbreviated proportions and began to be taken instead as direct assertions about the physical world. Thus we today think of a body's energy as itself "being" mc^2, even though we have no intuitive conception of the product of mass and velocity. The training of scientists undoubtedly encourages this kind of reification of symbolic mathematical entities, and Weil is therefore right to see in it the danger of a science that does not actually *think*. Beyond that, however, Weil seems to assume that any valid formula of physics should in principle be redeemable as a proportion involving intuitable physical quantities. "Science," she maintains, "has as its object the study and the theoretical reconstruction of the order of the world—the order of the world in relation to the mental, psychic, and bodily structure of man. Contrary to the naïve illusions of certain scholars, neither the use of telescopes and microscopes, nor the employment of the most unusual algebraic formulae . . . will allow it to get beyond the limits of this structure" (1951, 169). But if this assumption was true for mathematical physics at least well into the nineteenth century, it is no longer true.

In Hermann Minkowski's "spacetime" formulation of Einstein's special theory of relativity, first set forth in 1908, an invariant quantity designated the "spacetime interval" is defined for any two events: $s^2 = (ct)^2 - x^2$ (where s is the spacetime interval, t is the time interval between the events, x is the distance between the events, and c is a constant, the velocity of light in empty space).[13] Of course, since ct has units of distance, the literal meaning of $c^2t^2 - x^2$ is simply the difference between the distance separating two events and the distance light would travel in the time interval between the two events.[14] But if we represent time in terms of ct, the expression can be understood as a "spacetime interval" via an analogy with a rotation of coordinate axes in Euclidean space, where the distance between two points on a Cartesian plane is given by the Pythagorean theorem: $s = \sqrt{x^2 + y^2}$. Representing ct and x on respective axes of a Cartesian plane, we can perform a "hyperbolic rotation," in which angles are measured on arcs of a hyperbola rather than arcs of a circle as in regular trigonometry (Fig. 1). The hyperbolic rotation does in fact yield the relativistic expression $s^2 = (ct)^2 - x^2$.[15] If we then set c equal to unity and drop its units (distance per unit time), such that $ct = 1t$ or simply τ, substitution into the original expression yields $\tau - x^2$ as the "spacetime interval."

Clearly, because τ now designates time, the subtraction is intuitively meaningless. The operation can still be carried out, however, if we perform it on symbolic, dimensionless numbers and then "plug" the result back into units of "spacetime." Observe that to carry out the "spacetime" subtraction, we first had to convert c, the velocity of light, into the symbolic and dimensionless number "1," and then drop the dimensions of τ and x respectively.[16] Consequently, save for the symbolic conception of number uncovered by Klein, the very mathematical operations by which the

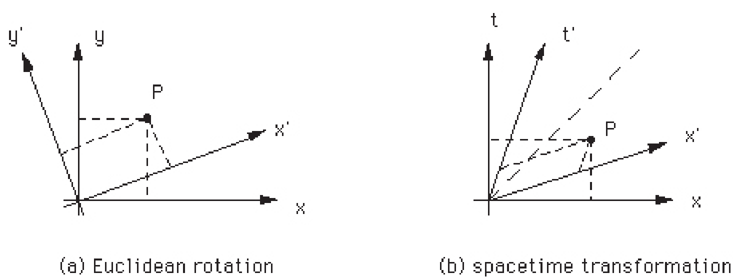

Fig. 1. The distance between the origin and point P in diagram (a) is invariant. Similarly, the space-time "interval" between the event at the origin and event P in diagram (b) is invariant.

spacetime interval is defined would be impossible. Here, that is to say, the symbolic form of representation cannot be intuitively redeemed even indirectly. Rather, the "spacetime interval" is an irreducibly symbolic entity.

If four-dimensional "spacetime" is devoid of intuitive sense, by contrast with the three-dimensional space and one-dimensional time of experience, why should it be accepted as real? The answer, in short, is that the concept of spacetime is an inevitable result of recognition in mathematical physics of the relativity of particular reference frames for measuring space and time. Thus Minkowski characterizes the theory of spacetime as the "*postulate of the absolute world*" (1952, 83). Such reasoning, we shall see, cannot simply be dismissed as thoughtless manipulation of algebraic symbols. At the same time, there is no denying that the Minkowski approach leaves us with the sense that "things" have somehow been replaced by relations among symbols.

Weil evinces a clear sense for this aspect of modern science when she comments, for instance, that in modern science order as expressed in algebraic symbols has become "a thing instead of an idea" (Weil 1965, letter to Alain of 1933), and that algebra "puts everything on the same level," since "things, once translated into letters, play an equal role in equations" (Weil 1968, 54). Indeed, for Weil, the deleterious effects of "algebraic consciousness" extend beyond mathematical physics per se. For in the contemporary world such consciousness has become socially reified, as it were, such that thought itself is now essentially "without a thinker":

> In all spheres, thought, the prerogative of the individual, is subordinated to the vast mechanisms which crystallize collective life, and that is so to such an extent that we have almost lost the notion of what real thought is . . . signs, words, and algebraic formulae in the field of knowledge, money and credit symbols in economic life, play the part of realities of which the actual things themselves constitute only the shadows, exactly as in Hans Anderson's tale in which the scientist and his shadow exchange roles. . . . (Weil 1958, 93)

The reification of method, so compelling in the lone Cartesian thinker or *ego cogito*, and so productive in mathematical physics, evidently has destructive consequences when embodied in social structures. The architects of seventeenth-century mechanics knew that algebraic formulae could not be simply read into nature. However, to the degree that a symbolic system of thought becomes socially reified, such that the thoughts of individual thinkers themselves are essentially constituted by the system itself, there is no truly individual thought remaining by which such a reification of technique could be even recognized.

For Weil, the reification of technique represents an abdication of individual thought and responsibility. But she further suggests that algebra could be relegated in science itself to the status of a "mere instrument" (Weil 1965, 3), an aid to the imagination in conceiving analogies (proportions). In other words, if algebra is reified technique, we should dereify it. Here, however, Weil underestimates the hurdles for a reorientation of science along the lines of Pythagorean number mysticism. As we have seen, in the context of modern mathematical science, there is no way of dereifying algebraic technique, at least not in the way Weil suggests. That could be done only by abandoning modern science per se, since in modern science algebraic entities are indeed "the thing." To be sure, in some sense Weil did wish for contemporary science to be, if not abandoned, at least conceptually reformulated at its very root. Whether that desire is justifiable is a question to which we presently turn.

Contemporary Science and Number Mysticism

Twentieth-century science introduces symbolic theoretical entities in principle incapable of being represented by the imagination, for example the "wave-particles" of quantum mechanics or the "curved space-time" of Einstein's general theory of relativity. For Weil, such a severing of ties between science and the imagination is symptomatic of something deeper and in itself more troubling: a hostility to thought itself, evinced in what she refers to in one passage as a "contempt for the principle of non-contradiction" (Weil 1951, 169). This contempt serves as a barometer, as it were, of the basic thoughtlessness of contemporary science. It represents more specifically a failure of the vital faculty of *attention*, for Weil the only spiritual resource that human beings ultimately could be said to possess. Attention, in the most fundamental sense, is a form of obedience to God. In her essay on school studies, Weil maintains that the key to a correct conception of intellectual endeavor is the realization that "prayer consists of attention." Therefore, "although people seem to be unaware of it today, the development of the faculty of attention forms the real object and almost the sole interest of studies" (1951, 105).

Weil's understanding of the spiritual significance of attention brings into focus her objection to the reification of technique in contemporary science and in contemporary culture in general. The reification of technique undermines the cultivation of attention and in so doing makes modern humanity unfit for prayer. In the specific context of science, it renders us unfit for an encounter with the beauty of the world possible only through a grasp of the paradox of necessity, the mysterious complicity between brute necessity and love. Contemporary science, on this interpretation, merely ushers to its logical conclusion a process of reification begun in classical science. Classical science, in the interest of Cartesian "mastery of nature," discarded the discontinuous, that which cannot be rendered under a concept of deterministic causality. Twentieth-century science proceeded to jettison continuity as well, leaving a kind of esoteric and "magical" science celebrated by the lay public precisely to the degree of its impenetrability.[17] Thus the college physics student who asks how light can be both a wave and a particle, or how it can have the same velocity with respect to two observers in relative motion, is liable to be told, "That's just the way it is," and expected to accept such a response with a kind of dazzled admiration.

There is no denying, it seems to me, the spiritual impoverishment Weil describes; it is definitive of contemporary scientific and technological culture. But is this impoverishment intrinsically related to specific contemporary scientific theories? This question is paramount, because it is one thing to diagnose a malady of institutional science and its system of education and quite another to indict contemporary science as such. The latter clearly leaves us in a much more pessimistic situation.

According to Weil, Einstein, in his special theory of relativity, simply translated two logically incompatible principles (the light postulate and the principle of relativity[18]) into algebraic formulae and then united them "as if they could . . . be simultaneously true, and derived equations from them" (Weil 1968, 49). But this is precisely what Einstein did not do, as is clear from the philosophical section of his paper on relativity (Einstein [1905] 1952).[19] Einstein arrived at his physical ideas not via thoughtless manipulation of algebraic symbols but rather via probably the most philosophically rigorous reflection on space and time since Leibniz in the late seventeenth century. Admittedly, one would not know it from many textbook accounts of relativity, which merely present the mathematical techniques of the theory. Einstein himself, however, demonstrated logically that the evident incompatibility of the invariability of the velocity of light and the principle of relativity rests on an invalid assumption in Newtonian physics regarding the absolutivity of space and time. His reflection on our intuitive knowledge of simultaneity resolves the contradiction while at the same time yielding insight into a mysterious and beautiful "complicity" in the very heart of nature, a preestablished harmony, if you will, between the demand for an absolute of thought (the velocity of light as a law of nature) and the world of empirical observation.[20] In no way does Einstein merely force together algebraically two conceptually incompatible principles.

A similar assessment obtains as regards Weil's objection to the quantization of energy in twentieth-century physics. Weil's objection to quantum mechanics is not the reintroduction of discontinuity per se but rather the manner in which discontinuity is reintroduced, namely, by simply forcing it together algebraically with the incompatible concept of energy, an essentially continuous quantity.[21] Contrary to Weil's analysis, we might observe that continuous space and time are themselves philosophically problematic, as the Greeks knew, and that classical science's conception of spatiotemporal continuity is arguably itself a mathematical idealization, as Leibniz pointed out. Current string theory, in fact, entertains the possibility that space and time are quantized, thus removing (should string theory be confirmed) the apparent conflict between the continuity of space and time and the existence of quanta.[22]

My purpose in discussing these examples is neither to absolve contemporary science nor to dismiss Weil's valid criticisms but rather to point out that Weil's charge of thoughtlessness against relativity and quantum mechanics is in some degree unfair—if not to institutionalized science and its system of education, at least to the creators of the theories. Had Weil lived long enough to study twentieth-century physics in greater depth, she would undoubtedly have revised her assessment. To be sure, it is a serious and damaging thing that prospective scientists are often or even typically initiated into their specialties via mathematical techniques divorced from genuine insight into natural phenomena. Fortunately, there are resources within contemporary science for overcoming this (having students read Einstein's scientific papers themselves, for example).

Indeed, Einstein is arguably the greatest number mystic in the history of science since the Pythagoreans. Reflecting on the vocation of the physicist, he avers that

> physical theory has two ardent desires, to gather up as far as possible all pertinent phenomena and their connections, and to help us know not only *how* nature is and *how* her transactions are carried through, but also to reach as far as possible the perhaps utopian and seemingly arrogant aim of knowing why nature is *thus and not otherwise*. Here lies the highest satisfaction of a scientific person . . . [that] one experiences, so to speak, that God Himself could not have arranged those connections in any other way than which factually exists, any more than it would be in His power to make the number 4 into a prime number. (quoted in Holton 1972, 366–67)

Einstein accordingly emphasizes that his general principle of relativity "implies the *necessity* of the law of the equality of inertial and gravitational mass" (1961, 69).[23] On this basis one could hope that the law of universal gravitation could be derived purely theoretically, a hope that in the general theory of relativity has been "realized in the most beautiful manner" (1961, 87). For Einstein, such insight into necessity, the revelation of the inherent mathematical beauty of the cosmos, is the essential aim of science.

Indeed, his attitude evinces a longing for reunion with the whole, an attempt to reach out to the universe itself. It is not so far from Weil's expressed conviction that loving anything less than the universe as a whole is a form of idolatry:

> Beauty is the only finality here below. . . . The love of this beauty proceeds from God dwelling in our souls and goes out to God present in the universe. . . . This is true only of universal beauty. With the exception of God, nothing short of the universe as a whole can with complete accuracy be called beautiful. (Weil 1951, 165)

When he discovered that his gravitational field equations rendered a previously unexplained disturbance in the orbit of the planet Mercury a simple matter of geometrical necessity, Einstein relates that "for a few days I was beside myself with joyous excitement." One can almost imagine him sacrificing a bull to the gods, as Pythagoras is reported to have done when he discovered the method for finding the mean proportional.

Nevertheless, in our present situation a more radical philosophical and theological reflection is needed. Weil's analysis, transcending as it does the spiritually trivializing compartmentalization and associated instrumentalization that degrade our science, points the way. Indeed, we should remind ourselves that the contemporary divide between the "hard" sciences and so-called humanities is a modern or at least Renaissance innovation deeply hostile to the genuine tradition of *liberal arts*, of which the Pythagoreans were the progenitors and which in its medieval form included both literary and mathematical subjects. A revitalization of liberal arts in the true sense would require the reinstitution of what once went under the name *natural philosophy*—not to be simply identified with what today goes under the name *philosophy of science*. Although early modern science called itself natural philosophy, it initiated the historical process by which the latter, traditionally a philosophical discipline distinct from metaphysics, fell into eclipse. Yet with the advent of modern "positive" science, especially modern *symbolic* science, natural philosophy is needed more than ever, not only as a mediating discipline or *metaxu* between physics and metaphysics but also as bridge across the contemporary divide between the sciences and the humanities more generally, and particularly, in light of Weil's emphasis on the spiritual crisis of modern science, between science and theology.

Nevertheless, traditional natural philosophy did not countenance the form of positive or "empiriometric" investigation of nature, distinct from natural philosophy per se, that defines science in the modern period.[24] Indeed, modern science in some sense replaced the object of traditional natural philosophy, namely, the being of experienced nature, with a constructed symbolic-mathematical object, and then implicitly cast this symbolic object as reality. For this reason, only a genuine natural philosophy, but reconstituted as a bridge to symbolic positive science, can furnish a truly critical perspective on modern science. It could contribute much to overcoming the artificial compartmentalization that so undermines science's claim to truth and fosters a merely utilitarian or technological conception of science, devoid of contact with any genuine conception of truth and goodness.

In connection with Weil's specific emphasis on the spiritual significance of physical labor, the symbolic conception of nature presents a particular challenge. As observed earlier, symbolic mathematics is in a sense itself a form of technology. Unlike what Weil had in mind when she analyzed physical labor in terms of the extension of the human body via machines, modern technology, starting with the steam engine of the industrial revolution, is, like the very symbolic mathematics that renders it possible, based on automation. For this reason modern machine technology is not so much about enhancing manual labor by extending the human body as replacing the human body with machines. By contrast to the merely instrumental machines of Weil's analysis, however, which inertly transmit the force of material necessity to the body, modern machines run automatically. This fact fundamentally changes the human relationship to work. If in our present age of science and technology physical labor is becoming obsolete, at least in advanced societies, the spiritual implications are from Weil's point of view quite grave. This is especially the case when, through its social reification, intellectual labor loses its analogy to physical labor.

Accordingly, Weil's analysis of the spiritual significance of manual labor requires further elaboration in light of the contemporary phenomenon of the automation of work. Her reflections on the spiritually destructive aspects of factory labor are closely tied both to her personal experience of the latter's physical brutality and to a Marxist analysis of alienated labor, where the worker is used by rather than using the machine.[25] Weil chastises Marx for failing to see that the problem of alienation is distinct from the question of who owns the "means of production" (Weil 1958, 1–24), but she does not seem to have envisioned the possibility that the physical brutality of factory work might be overcome not by a transformation on the model of genuine craftsmanship but by a form of automation that leaves alienation intact while potentially removing physical brutality altogether. It may not be physically brutalizing to press a button turning on a machine that runs itself, as opposed to operating the machine in the manner of a worker during the industrial revolution, but the work is meaningless in either case. Careful reflection is required to distinguish between those tasks in modern technological civilization for which automation is to be preferred and those for which manual labor has an essential role and could actually take on the spiritual significance envisioned by Weil.

Finally, we should not be blind to the mystical possibilities within contemporary science. In one sense modern science as symbolic reification is the very example of *personalizing* nature, and in so doing foreclosing the mystical relationship to necessity, but at the same time contemporary mathematical science somehow bespeaks a self-transcending necessity of its own, comes mysteriously bearing gifts of beauty and grace. So, for example, physicist Heinrich Hertz describes Maxwell's electromagnetic field theory: "It is impossible to study this wonderful theory without feeling as if the mathematical equations had some independent life of their own, as if they were wiser than ourselves, indeed wiser than their discoverer, as if they gave forth more than he put into them" (quoted in Park 1988, 356).

We need Weil's Pythagoreans, but just as much we need our own number mystics, our Einsteins. We need to pay attention to what they can teach us about how we in our scientific and technological age can love the universe the way the Stoics loved it when they said of the divine *logos*, the principle of necessity to the cosmos, "Lead me, and I will follow."

NOTES

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1. Besides Morgan's, the only other general study in English on Weil's interpretation of science of which I am aware is James Calder's "Against Algebra: Simone Weil's Critique of Modern Science and its Mathematics" (1987). On Weil's interpretation of thermodynamics see Pirrucello 2004. Studies in French include Armengaud 1983; Kaplan 1991; Sourisse 1991; and Meunier 1996. Pierre Kaplan's study in particular touches on some of the key issues with which the present essay is concerned.

2. Here Weil's position echoes that of Edmund Husserl in *The Crisis of the European Sciences* (1970), according to which authentic meaning formations must be redeemable in direct experience of the "life-world."

3. Sourisse discusses a related opposition in Weil's thought on mathematics, namely, between the constructive character of mathematics (after Kant) and its transcendent or ideal character (after Plato). The "blind necessity" of mathematics is essentially tied to the latter, yet mathematics paradoxically remains a construction.

4. This contrasts with the earlier period of the scientific revolution, led by planetary astronomy, in which the most notable figures, Copernicus and Kepler, were avid neo-Pythagoreans.

5. Newton asserts in the preface to his *Principia* ([1934] 1962, I:xvii) that geometry is founded on "mechanical practice," a view very much in line with Weil's analysis here.

6. See Morgan 2005, 37–47, on the development of Weil's understanding of work, including the less idealistic concept in Weil's later writings in comparison with the earlier dissertation on Descartes. For purposes of the present discussion, I am reading Weil's earlier, nonreligious interpretation of work through the lens of her later reflections, from the final years of her life, on the relationship between the love of God and the human encounter with the force of material necessity. This is justifiable, I believe, in light of Weil's own conviction that her previous life and thought had been a preparation for her later mystical encounter with God.

7. In the eighteenth century, *work* was defined as the product of a force acting through a distance (expressed algebraically, $W = F \times D$). By the classical work-energy theorem, the kinetic energy possessed by a moving body is defined by the work required to accelerate the body to a given velocity, or $mv^2/2$.

8. See on this theme also Calder 1987, 48–50. The affinity of Weil's thought for the phenomenological tradition in philosophy of science, especially Husserl's *Crisis*, cannot escape the attentive reader of her writings on science. Weil's thought on science, I believe, can be significantly illuminated by the findings of historical phenomenology of science, particularly the investigations of Jacob Klein in the history of mathematics. At the same time, historical phenomenology of science for its own part could benefit from the spiritual depth of Weil's treatment of science. A further aim of the present essay, then, is to bring Weil into conversation with contemporary historical phenomenology of science.

9. Husserl's locution in *The Origin of Geometry* (1970, 366), regarding the problematic status of the "life-world" in modern science.

10. The material in the following section (through page 361) is based on Cosgrove 2008.

11. Klein's seminal work on the subject is *Greek Mathematical Thought and the Origin of Algebra* (1968), in which he marks the emergence of the modern symbolic conception of number with Vieta's *Introduction to the Analytical Art* (*In Artem analyticen Isagoge*) of 1591. Several of Klein's later essays on the subject are collected in Klein 1985. There is no evidence that Weil was familiar with Klein's work.

12. Irrational numbers are numbers, such as the square root of 2, that cannot be expressed as fractions involving whole numbers.

13. As is customary, for convenience we here consider only a single dimension of space.

14. The velocity of light (c) carries units of distance per unit time, which when multiplied by t yields distance.

15. When a Cartesian coordinate plane is rotated about its origin by any angle, the distance between two points $s = \sqrt{x^2 + y^2}$ remains invariant. In a hyperbolic rotation the coordinate axes are rotated through a "hyperbolic angle," measured on an arc of a hyperbola rather than an arc of a circle as in regular trigonometry. The hyperbolic rotation yields, via analogous hyperbolic functions sinh and cosinh, the invariant ($s^2 = y^2 - x^2$ or $s = \sqrt{y^2 - x^2}$). In special relativity, the spacetime rotation yields $s^2 = (ct)^2 - x^2$, where c = velocity of light.

16. It is not possible to retain the expression *ct*, with its units of distance, and continue to refer to a "spacetime interval," asserting that time is, after all, being "measured" in units of distance. Although time can be *represented* in units of distance, it cannot be *measured* in units of distance.

17. By the loss of continuity in twentieth-century science Weil means most literally the indivisible *quanta* of energy posited by quantum mechanics. More generally, she refers to the eclipse of the concept of causal necessity (see Calder 1987). For Weil, indeed, twentieth-century science exhibits all the essential characteristics of magic—the drive to control nature, lack of rational insight into how or why its techniques work, esoteric doctrine passed down among a class of experts, and so forth. In *Oppression and Liberty* she imagines "a civilization in which all human activity, in the sphere of labor as in that of speculative theory, was subjected right down to matters of detail to an altogether mathematical strictness, and that without a single human being understanding anything at all about what he was doing; the idea of necessity would then be absent from everybody's mind, and in far more radical fashion than it is among primitive tribes which, our sociologists affirm, are ignorant of logic" (1958, 95).

18. The light postulate asserts that the velocity of light is a universal constant. The principle of relativity states that the laws of nature are the same for all inertial (nonaccelerated) frames of reference. If the invariability of the velocity of light is a law of nature, it would seem, it cannot be the same for frames of reference in motion relative to one another, and thus must violate the principle of relativity.

19. I can find no evidence in Weil's writings of direct familiarity with Einstein's paper. Kaplan, in his otherwise valuable essay (1991) on Weil and algebra, surprisingly takes Weil's interpretation of Einstein at face value.

20. Einstein's paper "On the Electrodynamics of Moving Bodies" ([1905] 1952) begins with a philosophical reflection on time, in which he notes that all our measurements of time rely on determinations of simultaneity (between, for instance, the second hand on my watch sweeping past 12 and a runner crossing the finish line some distance away). He further observes that distant simultaneity is never directly perceived, since sense intuition of distant events relies upon signals transmitted at finite velocity. If distant simultaneity is to be intuited indirectly, Einstein argues, we require an absolute velocity, which may be regarded as unity. Is there such a velocity? Yes, the velocity of light. This result in turn renders space and time, that is, measured lengths and measured intervals of time, relative to the frames of reference in which they are measured.

21. Energy as originally defined in terms of work (the product of force and distance) is a function of space, which latter is essentially continuous. Weil, as both Morgan and Calder emphasize, welcomed the reintroduction of discontinuity into scientific thinking, regarding it as a vital correction to the exclusive emphasis on continuity of classical mechanics, which, had it been thought through instead of swept under the rug algebraically, could have revitalized modern science (see Morgan 2005, 53–58; Calder 1987, 58–60). For Weil's account of quantum mechanics, see "Reflections on Quantum Theory" (Weil 1968, 49–64).

22. Alfred North Whitehead, in fact, argued that *perceptual* space and time are in effect quantized. Time, according to him, is an abstraction from the passage of events, and an event is temporally given to perception solely as a *duration* or "concrete slab of nature" (Whitehead [1920] 2004), 53).

23. Gravitational mass is the force associated with the weight of bodies; inertial mass is the force of resistance to acceleration.

24. The term *empiriometric*, after Jacques Maritain, highlights the bracketing of metaphysics in modern science via the reconstruction of nature in terms of mathematically idealized experimental models. On the indispensability of the distinction between, albeit essential relatedness of, positive science and natural philosophy, see Maritain 1951. Weil's negative estimate of twentieth-century physics suffers somewhat from the absence of a clear distinction between natural philosophy and positive science. Here is a case, ironic in view of her search for bridges, where to an extent Weil's chief virtue as a thinker, namely, her aversion to compartmentalized knowledge and her desire for a unified view of the whole, works against her. For her objections to modern science are in reality motivated by a mixture of distinguishable scientific and philosophical considerations. Positive science itself, however, is not always obliged to arrest its progress while philosophical problems, however genuine, are being resolved.

25. During the period 1934–35 Weil took a number of factory jobs through which, she relates in correspondence to her friend Fr. Perrin, she received the "mark of a slave" (Weil 1951, 66–67).

REFERENCES

Armengaud, Françoise. 1983. "Simone Weil et la science grecque. Richesse et ambiguïté d'une interpretation." *Cahiers Simone Weil* VI-I (mars): 1–15.

Calder, James Gordon. 1987. "Against Algebra: Simone Weil's Critique of Modern Science and Its Mathematics." *Explorations in Knowledge* 4:47–73.

Cosgrove, Joseph. 2008. "Husserl, Jacob Klein, and Symbolic Nature." *Graduate Faculty Philosophy Journal* 29 (1): 1–25.

Descartes, René. 1985–91. *The Philosophical Writings of Descartes*. 3 vols. Trans. John Cottingham, Robert Stoothoff, Dugald Murdoch, and Anthony Kenny. Cambridge: Cambridge Univ. Press.

Einstein, Albert. [1905] 1952. "On the Electrodynamics of Moving Bodies." In *The Theory of Relativity*, trans. W. Perrett and G. B. Jeffery, 37–65. New York: Dover.

———. 1961. *Relativity: The Special and General Theory*. 15th ed. Trans. Robert W. Lawson. New York: Random House, Wings Books.

Galileo. 1967. *Dialogue Concerning the Two Chief World Systems*. 2d ed. Trans. Stilman Drake. Berkeley: Univ. of California Press.

Holton, Gerald. 1972. "Mach, Einstein, and the Search for Reality." In *The Twentieth Century Sciences: Studies in the Biography of Ideas*, ed. G. Holton, 344–81. New York: W. W. Norton.

Husserl, Edmund. 1970. *The Crisis of the European Sciences*. Trans. David Carr. Evanston, Ill.: Northwestern Univ. Press.

Kaplan, Pierre. 1991. "La critique de l'algèbre à la lumière des idées de Simone Weil." *Simone Weil et les langues (Recherche sur la philosophie et langage)* 13:165–77.

Klein, Jacob. 1968. *Greek Mathematical Thought and the Origin of Algebra*. Trans. Eva Brann. New York: Dover.

———. 1985. *Jacob Klein: Lectures and Essays*. Ed. Robert B. Williamson and Elliot Zuckerman. Annapolis, Md.: St. John's College Press.

Maritain, Jacques. 1951. *Philosophy of Nature*. Trans. Imelda C. Byrne. New York: Philosophical Library.

Meunier, Loïc. 1996. "Simone Weil et la science." *Cahiers Simone Weil* XIX-4 (décembre): 373–95.

Minkowski, H. [1908] 1952. "Space and Time." In *The Theory of Relativity*, trans. W. Perrett and G. B. Jeffery, 75–91. New York: Dover.

Morgan, Vance. 2005. *Weaving the World: Simone Weil on Science, Mathematics, and Love*. Notre Dame, Ind.: Univ. of Notre Dame Press.

Newton, Isaac. [1934] 1962. *Mathematical Principles of Natural Philosophy*. Trans. Andrew Motte, revised by Florian Cajori. 2 vols. Berkeley: Univ. of California Press.

Park, David. 1988. *The How and the Why*. Princeton: Princeton Univ. Press.

Pirrucello, Ann L. 2004. "Simone Weil and the Foundations of Science: The Missing Third Principle." *Cahiers Simone Weil* XXXVII-2 (June): 137–54.

Sourisse, Michel. 1991. "Le langage des mathématiques chez Simone Weil." *Simone Weil et les langues (Recherche sur la philosophie et langage)* 13:251–63.

Weil, Simone. 1951. *Waiting for God*. Trans. Emma Craufurd. New York: Harper and Row.

———. 1952. *The Need for Roots*. Trans. A. F. Wills. New York: Routledge.

———. 1956. *Notebooks*. Trans. Arthur Wills. London: Routledge and Kegan Paul.

———. 1958. *Oppression and Liberty*. Trans. Arthur Wills and John Petrie. London: Routledge and Kegan Paul.

———. 1965. *Seventy Letters*. Trans. Richard Rees. London: Oxford Univ. Press.

———. 1968. *On Science, Necessity, and the Love of God*. Trans. and ed. Richard Rees. Oxford: Oxford Univ. Press.

———. 1987. *Science and Perception in Descartes*. In *Formative Writings: 1929–1941*, trans. Dorothy Tuck McFarland and Wilhelmina Van Ness. Amherst: Univ. of Massachusetts Press.

Whitehead, Alfred North. [1920] 2004. *The Concept of Nature*. New York: Prometheus Books.