The Revolution in the Concept of Space

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ONE result of the revolution in physics from Newton through Einstein is the new technological power. Another result, less widely known, is a radically new world-view with profound implications for religion and ethics. Fundamental to the revolution has been the working out of a sensible concept of space and time.

Both Newton and Huygens assumed that space was an immaterial room containing some kind of "ether." To Newton the "ether" was air-like, allowing light to speed from its source as musketballs are shot through the air. Musket-reports gave Huygens his cue. Light, he suggested, "spreads as sound does by spherical surfaces and waves" through an "ether" that is jelly-like.

The classic Michelson-Morley experiment with light about two hundred years later produced no evidence of an "ether" of any kind. It has since been concluded that **space** is all that exists among material bodies, where it is called "interspace," or "the field," and that light has both wave and particle forms. When a photon of light travels from its source to another body, it travels as waves in the spatial field; when it lands, it lands as a particle.

Space is Physically Real

Experiments in the nineteenth century by Oersted, Faraday, and Hertz, plus the mathematics of Maxwell, showed that light waves were electromagnetic radiation. Many other kinds of radiation have been discovered that travel with the speed of light and differ only in wave-length. The list includes wireless, radio, and Hertzian waves; radiant heat and infra-red rays; visible light and ultra-violet rays; X-rays, gamma rays, and cosmic rays—a series known as the electromagnetic spectrum.

In the Newtonian view, forces act along straight lines connecting particles; they may act at a distance; and their strength depends on distance alone. In the new view, forces may act along a line **perpendicular** to the line connecting particles (as when the closing of a circuit deflects a magnetic needle); they act on their **immediate neighborhood** (in electric and magnetic waves); and their strength depends on the **velocity** (involving time) of the source particles as well as on the distance from them.

The formulation of Maxwell's equations is "the most important event in physics since Newton's time," for these equations express a new law representing "field structure." So wrote Einstein and Infeld in **The Evolution of Physics.** The field is "something real." Once produced, a magnetic field coils round a moving electric field, and an electric field coils round a moving magnetic field **independently of their source.**

While the mechanical view confined law to the points at which bodies were present, the field-view extends law **throughout space.** Maxwell's laws, moreover, depend not on "material actors," but on the field forces themselves—and so on motion and time. In the new materialism space is not only continouous and indivisible; it also includes time and motion.

The "empty space" of Leucippus and Democritus had no physical properities. The space of Galileo and Newton was likewise "empty." It had mathematical properties, but was merely a timeless immaterial continuum opposed to the world of granular matter. The space of Einstein has "both mathematical and physical properities" and is not opposed to anything. It includes time. It is boundless, active, and real.

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Time is the Movement of Space

Late in the nineteenth century the different kinds of energy were classified as mechanical, electrical, chemical, and radiant, with light and heat waves regarded as forms of radiant energy. All forms were recognized to be modes of motion. It was discovered that energy is neither created nor destroyed by transformation from one form to another.

While the "conservation of energy" was being established, another investigation was formulating the "degradation of energy," also known as "increase of entropy." In 1824 Carnot pointed out that a heat-engine can transform heat into work only through a drop in temperature. For the engine to run, heat must pass from the source of heat to the condenser; the hot body becomes colder, the cold body hotter.

Building on Carnot's work, Clausius discovered that the flow of heat is irreversible. An engine may transform the whole of a given quantity of work into heat, but it cannot transform the whole of a given quantity of heat into work. Thus the flow of heat-energy tends to become less available for the performance of work, for useful mechanical energy. Clausius expressed this tendency as an increase in the "entropy," or the ratio of useless to useful energy.

Through the rigorous mathematical work of Clausius, Helmholtz, and William Thomson, the subject of thermodynamics was organized with "conservation of energy" as its first law and "degradation of energy" as its second. In **quantity** the energy is conserved; it is solely in **quality**, or in capacity to perform work, that energy becomes degraded. The limit of degradation is a state of **uniformity, equilibrium, or homogeneity between the given body and its environment.** This means that the cosmos—that is, the entire collection of bodies in space—forever tends to become finely divided, spread out, and evenly balanced. The cosmos is a l w a y s and everywhere "running down."

Is there a complementary process that always and everywhere "wind up" the cosmos? The answer to this fundamental question has come chiefly through the patient research of Einstein in developing the **general** theory of relativity, which deals with bodies in **non-uniform** motion, such as an automobile accelerating, or a stone falling freely toward the earth in gravitational acceleration. The question arose as to whether all bodies in the cosmos, even those in apparently **uniform** motion, were moving in a gravitational field. The reply was in the affirmative. Only at an infinite—or meaningless—distance from a material body would gravitational influence be entirely absent. Hence the "inertial systems" considered by Galileo, Newton, and the **special** theory of relativity did not actually exist! There was **no** material frame of reference relative to which a body could move in strictly **unifrom** motion.

According to **general** relativity, every motion in the cosmos must be considered to curve in lines of gravitational force, since gravitation operates more or less intensely throughout the cosmos. Hence **every wave-train or particle-motion is more or less curved.** A body moves in a curve determined by all the masses in the cosmos, whether of particle or of field. As a so-called straight line is really only part of a great curve, so a body's "inertia" is only part of a universal system of gravitation.

Particles move in the curved physical field, according to the time-law of "least action," along natural routes called "geodesics" in Riemannian geometry. A geodesic is thus the "smoothest curve" in the space-time world. The elliptical path of the earth, for instance, is the smoothest curve the earth can take in relation to its fellow planets, the sun, and all other masses in the cosmos. Thus the earth does not obey specific gravitational forces, as in New-

ton's theory; it rather settles to a line of action through universal adjustment.

The distinguished scientist Richard C. Tolman has observed that, in Einstein's general theory of relativity, universal energy includes not only material bodies and radiation but **gravitation** as well. Hence the constant supply of available energy required to keep the universe going is always present in the form of gravitation. "This energy," says Tolman, "can be regarded as coming from the potential energy of the gravitational field associated with Einstein's pseudo-tensor density." **Through electromagnetic radiation the cosmos is always running down, but through gravitation it is always being wound up.**

Time is now seen to be this irreversible cosmic motion, which can only be the infinite movements of material space — spontaneous, expansive, and vanishing cyclical movements. Time, then, is nothing more nor less than spatial movement understood as an endless evolution. Gravitation is the creative phase of time, while radiation is its destructive or absorptive phase.

Space and time, in the new view, are inseparable. They are not two opposing principles: time is the first of the four dimensions of space. Space is the boundless spontaneous whole in which time serves as distinctions. Space is the material actor having time as its acts. Space is the substantial self, or soul, of which time is the intention, the "internal expression." Space is peace, the beginning and end of desire. Space is **deus sive natura** in a Spinozistic but non-mechanistic philosophy.

Space, or the boundless self, may be termed an **individual** in the sense of an **indivisible** thing. As such, it is the **only** individual and **the ground of individuality in every organic structure.** Though indivisible, space is nevertheless not indistinguishable. It is **infinitely distinguishable.** It is **infinitely distinguishable** through endless time. Through time unbounded space forever distinguishes itself into the changing field of physical, or moving, space-time events intersecting in the mathematical or motionless field of point-instants. Through time space **acts;** through the motionless mathematical field, which we may call the mind, space can **know.**

Bodies are Material Space

Profound as are the changes in our concepts of space and time, the revolution in natural science cannot be fully appreciated without a consideration also of **corpuscular** matter which, in a word, is regarded no longer as an eternal array of solid atoms, but as progressively emergent (or created) forms of an underlying material space.

The solid-atom concept of Dalton, derived from Newton and Democritus, was taken to be scientific bedrock until, in the nineteenth century, the study of electrical phenomena in liquids (electrolysis), in gases (luminous discharge), and in solids (spectrum analysis) converged to establish the existence of the electron instead of the atom as the most elementary particle.

Then the researches of Planck, Einstein, Bohr, de Broglie, Schroedinger, and Heisenberg in connection with the "quantum theory" suggested that the most elementary particle could be explained as a packet of "material waves" in space. This means that no particle is eternal. The electron, or any other particle of the atom, is created when material waves in space converge and coalesce into a spinning wave-packet. Material waves must somehow be associated with gravitation. It would seem that plain gravitational waves belong to "the field," while spinning gravitational or material waves are space in corpuscular form.

We are now prepared to picture what we know of the entire cosmic process. As material waves in cosmical repulsion move along vastly circular natural paths of gravitation, they interact and become polarized in spinning particles through which the atomic systems are

built up. This construction may be assumed to proceed according to the esthetic principle of "least action," by which conflicts are resolved into harmonies, uneven pressures into balanced adjustments, rough lines into the smoothest possible curves.

The electrical character of the atom is manifested in its radiation of electromagnetic waves, which have a spectrum running from the longest radio waves through heat and light to the shortest cosmic rays. The cosmos thus exhibits organized matter sandwiched in between the primary field of material waves and the secondary field of electromagnetic radiation. The electromagnetic field is apparently a by-product of creating organized matter through material waves in space. Through the material-wave field of gravitation the organized world is created; through the electromagnetic-wave field its superfluous energy is expended; through both fields, in a dynamic balance of anabolism and katabolism, it is maintained in esthetic structure.

We see that space is not a inert empty room. It is the material mother of countless forms of itself, the mother of creative waves, corpuscles, radiation. Some of the primary waves become protons and electrons; some of these particles become organized into atoms and molecules; some molecules aggregate into molar bodies. Particles and larger bodies, through gravitational pressure, converge and swirl into vast spiral nebulae, or galaxies, in the "expanding universe." Where the pressure is most intense there will be dense aggregations of bodies into stars, exhibiting high temperature with profuse radiation of high-speed particles and electromagnetic waves. Regions of less pressure in the spiral nebulae will be characterized by smaller bodies, including cosmic vapor and dust.

Where gravitational pressure within a star is so great that the start explodes as a heavenly "nova," it means (we are told) that inner shells of the star's atoms have broken down, with the output of tremendously brilliant radiation. A still greater pressure, resulting in a "super-nova," means that the free electrons have collapsed into the central protons to form neutrons.

In 1939 Robert A. Millikan suggested that cosmic rays (composed of "superpower particles" and extremely penetrating electromagnetic waves) could be explained if the most abundant elements found in nebulae suffered a conversion of their entire nuclear mass into radiation. The reconversion of radiation into creative gravitational energy would, of course, be the final step in the cosmic cycle initiated by space energizing through time.

If God be conceived as the absolute, as the omnipresent and omnipotent individual worshiped by Jesus of Nazareth, then God and active real space are but two names for the same reality; and God's spirit, through which the world is created and judged, is the same as space's evolutionary, or temporal, expression.