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Science and Hypotheses on Unobservable Domains of Nature

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Hypotheses in science are not derived from observations : they are applied to observations. The distinction marks the difference between induction and deduction in the method of the empirical sciences ; more precisely, between induction from particular (and unwarrantedly generalized) observations and hypothetical deduction to predictable, and in the confirmed case predicted, observations.

Einstein has emphasized that the fundamental premises of scientific theories are the free products of imagination ; they are only subsequently tested for « fit » by the rigorous methods of deductive reasoning. Thus the criterion for a scientific hypothesis is not whether or not it is derived from observation, but whether or not it can elucidate observation with optimum economy (Einstein also remarked that in science one is « seeking for the simplest possible scheme that will bind together the observed facts. »)[1] Since, according to the Mach--Duhem-Poincaré principle, an indefinite number of theories may fit any given observation, criteria such as simplicity, consistency, elegance, and consistency with other hypotheses are crucial elements of the decision whether or not to validate a hypothesis. The scientific community normally adopts that hypothesis among several contending ones which, in addition to fitting an otherwise anomalous or uneconomically explicable observation, is also the most economical : it is simple, elegant, free of unwarranted assumptions, and has optimum fit with already validated neighboring hypotheses.

It makes little difference to the validation of scientific hypotheses whether or not their basic premises have direct referents in the realm of observation ; what counts is the deductively verified fit with the data to be explained. If this fit responds to criteria such as those mentioned above, the hypothesis is worthy of validation and becomes an element in received scientific knowledge.

The Conquest of Intrinsically Unobservable Domains

In the history of empirical science, working hypotheses and validated theories have advanced from the directly observable domains (what Northrop called science's « natural history period ») to increasingly unobservable domains (in the « mature science

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1 [Einstein 1934].

period »). Galileo derived his law of gravitation from the observation of balls rolling down inclined planes and spheres dropping to the ground ; Newton generalized such laws and applied them to both observable domains on the surface of the Earth and to unobservable domains on heavenly bodies. Astronomers continue in this tradition by explaining physical phenomena in reference to universal laws, regardless of whether they are directly observable or not. An unobservable phenomenon, such as a star or planet whose radio or light signal is blocked or washed out by other stellar bodies, is explained in reference to lawful interaction with observed phenomena, e.g., through gravitational attraction with seen or instrumentally observed stars and planets.

In the above cases unobservability is not an intrinsic condition : it is due to the fact that from our position on this planet our instruments of astronomical observation do not convey data on the phenomenon. There are, however, instances in which unobservability is an intrinsic characteristic of phenomena. For example, the emission of a photon in an atomic reaction is intrinsically unobservable : by the time the light quantum leaves the atom the electrons will have rotated millions of times around the nucleus. Thus while light (at least of certain wavelength) is an observable, its quantal emission can never be that.

Intrinsic unobservability applies to almost the entire domain of quantum physics. It is at the root of the famed injunction pronounced by Niels Bohr, not to ask what the quantum-level phenomena are « in-themselves », thus avoiding conceivably fruitless debates regarding the explanation of paradoxical quantum properties such as particle-wave duality, Heisenberg uncertainty, and space-time nonlocality. The injunction, which Einstein never accepted, does not prevent quantum physicists from advancing hypotheses regarding the mathematically expressible features of subatomic events and applying them to explain observed phenomena beyond the Planck-dimension.

Hypotheses in quantum and cosmological physics penetrate ever further into the intrinsically unobservable elements of what scientists assume to constitute the total, but only partially observed and observable, field of reality. Multidimensional spaces, supersymmetric particles, phase changes during and following the Big Bang, virtual particles, particle synthesis, black-holes, to mention but a few, are among the basic tools of current cosmological theories. They join quarks, exchange particles, color forces and other intrinsically unobservable events in quantum physics. In consequence the current physical world picture is populated with entities that are not merely beyond the range of sensory observation due to macroscopic or microscopic size and / or location in space and time ; they are also beyond the range of sensory observation in having properties that no macroscopic being equipped with sense organs of any acuity on any location in space and time could observe.

The exploration of domains ever further removed from intrinsic observability has deep roots in Western science. Democritus pioneered the process by referring observable matter to indivisible and unobservable ultimate components called atoms. Dalton and Lavoisier discovered the atomic constitution of gaseous matter, and their atoms could subsequently be instrumentally observed. However, they proved fissionable and hence were disqualified from serving as indivisible ultimate entities. Rutherford proposed a model of the internal substructure of atoms, pushing the realm of observation and experiment one step further into the realm of directly unobservable micro-phenomena. As instrumentation became more refined and experimental tools more powerful, the atomic nucleus itself proved fissionable. The investigation of physicists shifted into the domain of subatomic particles and forces. And that was not all : when Murray Gell-Mann suggested that the known particles are made up of still more basic elements called quarks, theory and experiment entered the subparticle level. There are indications that inquiry in physics is about to move into the domain of subquantum phenomena. The next revolution in science may be the elaboration of what John Wheeler dubbed « vacuum physics »[2] and this writer called « subquantum dynamics. »[3]

The Challenge of the Quantum Vacuum

That the vacuum level of physical reality is intrinsically unobservable does not deter scientists ; the challenge it presents to theory goes beyond this fact. It begins as we consider Maxwell's

2 [Wheeler 1987].

3 [Laszlo 1993] & [Laszlo 1995].

theory of electromagnetism. When we take the equations known as the vacuum field equations we must note that even though they describe waves propagating in a field, there are no sources for that field — the electron is a mathematical point and cannot be a field source. Yet the field in which electrons propagate stores a very large amount of energy, known as the zero-point energy (ZPE).

The energy density of the zero-point field (ZPF) is an anomaly in itself. It surfaces when one applies Heisenberg's uncertainty principle to infinitely small locations. As one moves into progressively smaller locations one is required to specify the position of the particle with increasing accuracy. This, however, means that its momentum becomes increasingly uncertain. If position would be fully specified, momentum would go to infinity. In quantum electrodynamics the problem is resolved by postulating an infinite number of oscillators in describing the energy of the ZPF.

Yet the anomaly of vacuum energy is not so readily resolved. Wheeler calculated that, if quantum laws hold at the Plancklength of 10^{-35}, the energy density of the ZPF must be 10^{94} g/cm^3. This, however, is a problem : according to Bohm the zero-point energies of the vacuum would exceed all the energies bound in matter by a factor of 10^{40}. If so, given that relativity theory requires the gravitational potential of the universe to be proportional to its energy content, matter particles synthesized in the wake of the Big Bang should have collapsed the young universe back into a singularity, rather than allowing particles to form atoms and clump together into galaxies that expand in space-time.

For most of this century, the physics community treated the anomaly of vacuum energy through the mathematical stratagem of renormalization. This eliminated infinities and quasi-infinities from the equations and produced quantitative relationships that seemed to fit crucial domains of observation. However, in recent years physicists have taken a fresh look at the properties of vacuum energies and attempted to link them with the properties of matter-energy systems in the observable domain.

Phenomena that require attribution as effects of the ZPF have been known for a number of years. For example, when electrons in atomic nuclei transit from one energy state to another, the photons they emit exhibit a frequency that is slightly shifted from its normal value ; the difference is ascribed to the effect of the ZPF. In addition to this Lamb-shift, there is also the Casimir effect. It is produced as zero-point energies create radiation pressure on two closely spaced metal plates. Between the plates some wavelengths of the ZPF are excluded, thereby reducing the energy density with respect to the density of the field outside. The pressure pushing the plates together is attributed to the difference in vacuum energy density between the two sides of the plates.

Further investigations have been reported recently regarding dynamic effects originating in the vacuum. They refer to the Davies-Unruh effect postulated in the 1970s. Paul Davies and William Unruh argued that constant-speed motion through the quantum vacuum will exhibit its spectrum as isotropic, whereas accelerated motion must produce a thermal radiation that breaks open the directional symmetry. The effect is too small to be measured with physical instruments, but its consequences can be investigated. In a paper published in February of 1994 Bernhard Haisch, Alfonso Rueda and Harold Puthoff argue that accelerated motion through the vacuum may give rise to the force of inertia.[4] Originally defined by Galileo as the property of a material object to either remain at rest or to move uniformly in the absence of external forces, the concept of inertia was expanded by Newton's second law (F = ma) into a fundamental quantitative property of matter. However, nobody could show how inertia would be associated with material objects. Earlier in this century Mach- suggested that it should be related to all other matter in the universe, and Einstein hoped to integrate Mach-'s principle into general relativity. Neither scientist could offer a convincing demonstration. The Haisch, Rueda, Puthoff hypothesis now offers a mathematical demonstration that inertia is a Lorentz force that originates at the subelementary level and produces opposition to the acceleration of macroscopic objects. The accelerated motion of objects through the vacuum produces a magnetic field, and the particles that make up the objects are deflected by this field in accordance with Lorentz's calculations. The larger the object the more particles it contains, hence the stronger the deflection and greater the inertia. Inertia is thus a form of

[4] [Haisch 1994].

electromagnetic resistance arising in accelerated trames from the spectral distortion of the ZPF.

The physical field that results from the unification of electromagnetism with quantum theory could be significant in the explanation of phenomena on both micro and macro levels. In regard to macrolevel systems, research is now focusing on the action of quantum-fields on living tissues, including neural networks. In biological systems coherent interactions are observed within molecules, between molecules, as well as among dipole clusters in distinct cellular and anatomical structures. In the past, such phenomena have been explained in terms of long-range electromagnetic correlations between physically separated oscillating electric dipoles. The alternative explanation now makes reference to the anomalous connection between physically separated superconductors known as the Josephson effect. According to quantum field theory, Josephson junctions generate fields of quantum potentials consisting of a magnetic vector potential and an electrostatic scalar potential. These can be seen to modulate the observed correlation between neighboring superconductors and cellular assemblies.[5] The fields may also reinforce communication between assemblies of neurons in the brain. Spectral patterns of specific frequency associated with nerve firings are said to impart information to the field, with the field in turn imposing coherence on the nerve firings. Thus the quantum field constitutes an underlying regulatory system that alters non-synaptic communication between assemblies of neurons.[6] Due to the input-sensitivity of chaotic attractors, the subtle effects can become amplified and affect the information-processing functions of entire cerebral regions.

Not only the effects, also the origins of vacuum energies are the subject of intense investigation. Harold Puthoff argued that either vacuum energies were fixed arbitrarily at the birth of the universe as part of its boundary-conditions, or they have been generated by the motion of charged particles in the course of time. His theory supports the latter alternative.[7] Puthoff shows that the energies of the ZPF are generated by the motion of quanta, and in turn « drive » the motion

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5 [Del Giudice 1989].

6 [Rein 1993].

7 [Puthoff 1987].

of quanta. This produces what he calls a self-regenerating cosmological feedback cycle. He calculates the properties of the electromagnetic radiation from charged particles produced by quantum fluctuations throughout space and time. Using the inverse square law to estimate the radiation produced by charged particles in acceleration, Puthoff finds that the average volume distribution of such particles in spherical shells surrounding any given point source is proportional to the area of the shell. The sum of radiations from surrounding shells yields a high-energy density radiation field identified as the ZPF. Puthoff's calculations show that the absorption and reemission of ZPF radiation by a ZDF-driven dipole oscillator yields a local equilibrium process. The radiation field generated by the ZPF-driven dipole just replaces the radiation absorbed from the ZPF background, doing so on a detailed balance basis with regard to both frequency and angular distribution. The feedback loop of charged particles generating the ZPF, and the absorption of that field by the particles, is self-regenerating on the large scale : the local zero-point energy background experienced by a given charge is due to radiation from the motion of charged particles induced in the zero-point field throughout the rest of the universe.

Puthoff's theory yields some notable results. They demonstrate a quantitative relationship between ZPF density, and the average density of matter in the universe as well as the size of the universe. They also offer an explanation of the « coincidence », first noted by Dirac, between the ratio of the electromagnetic force of an electron and a proton and the gravitational force acting between these particles, and the ratio of the size of the universe (the Hubble distance) with respect to the size of the electron.

Extensions to Speculative Domains

Speculative theories on the frontiers of science extend the penetration of current hypotheses into intrinsically unobservable domains. A case in point is David Bohm's theory of the implicate order. This dimension of reality — more fundamental, according to Bohm than the observed explicate order — is a vacuum-based holofield where all physical events are simultaneously and eternally compresent. Although the entire range of physical (and many anomalous psychical) manifestations are said to be consequences of interaction with the implicate order, no conceivable natural observer could perceive that order in itself.[8]

The field of anomalous psychical phenomena — collectively known as psi-phenomena — is another field that science may penetrate in coming years. Hitherto, the elusiveness of psi-data forced many scientists to regard the phenomena not only as unobservable, but as downright non existent. However, in recent years the data have been accumulating, yielded by repeated, statistically evaluated experiments. As Russell Targ observed :

> « Our significant accomplishment as psi-researchers over the last two decades, is that psi is no longer elusive. We can demonstrate it when we need it for study and investigation. »[9]

Targ also noted that, when all is said and done, the findings are all data : the task is now to discover where they come from. Here concepts such as Bohm's holofield, and this writer's ψ-field — both of them traced to the quantum vacuum as the physical basis — offer promising avenues to explore. Systematic research in this area could link front-line work in physics with analogous work in psychology, neurophysiology, and consciousness research. As part of the scientific revolution centered on the penetration of the subquantum level of physical reality, it may answer puzzling questions in the hitherto neglected farther domains of human experience and bring significant advance toward the unification of the contemporary scientific world picture.[10]

Science (unlike some conservative scientists) is essentially an open system, unfettered by the limits of observability. Through constructive dialogue between leading-edge theoreticians and the body of mainstream theorists and experimentalists, it penetrates progressively deeper into the intrinsically unobservable domains of what most scientists presume is the total, but not totally observable, field of reality. It is reasonable to expect major breakthroughs in this regard in coming years. Concepts previously in the realm of speculative philosophy are increasingly subjected to quantitative

[8] [Bohm 1980].

[9] [Targ 1994].

[10] [Laszlo 1993].

analysis and made available for experimental testing in terms of their deduced empirical consequences. These developments are not an aberration in science, but represent the unfolding of developments that were initiated in Hellenic natural philosophy. They expand the frontiers of science and bring ever more of the natural universe within the compass of rigorously examined and experimentally tested knowledge.

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