What is an Object?

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Physics cannot be conducted without a proper definition of the word 'object'. Here I show that current misconceptions about this word, as well as about the scientific method, are the root of invalid hypotheses in Physics.

Keywords: object, scientific method, hypothesis, spacetime, black hole, point particle, duality.

Why the definition of the word *object* is crucial in Physics

Few will disagree that the study of motion is central to Physics. Without exception every introductory textbook begins by explaining velocity, acceleration, and momentum, terms which subsequently serve as foundations for higher concepts such as force, mass and energy. [1] Motion irrevocably involves a physical object. [2] Hence, the study of Physics is first and foremost the study of objects. Indeed, the most important topics of contemporary Physics revolve around physical objects. Hawking [3] states that space-time is an object, a black hole is widely considered to be a dynamic object [4, 5], and Particle Physics is defined as the study of motion of subatomic

objects known as 'particles' [6]. Therefore, in Physics, we have no alternative but to define what we mean by *object*.

It turns out, however, that in the entire history of Physics no one has ever bothered to define this fundamental term. Not a single textbook begins by defining what an object is. Therefore, in this paper, I begin by highlighting the deficiencies of three informal versions currently in use, and then propose a proper definition. I subsequently show that this fool-proof definition renders invalid widely-accepted, *sine qua non* hypotheses proposed by relativity and quantum theory.

The definition of the word *object*

The following are common usages of the word object:

a. a volume [7]
b. the aggregate of locations [8, 9]
c. something we can touch or see [10]

However, upon closer inspection, not one of these definitions passes a rigorous analysis.

a. A volume is the amount of space displaced by an object, a concept that tacitly embodies motion. The object is the fish; the water it displaces is the volume. The observer had to *sweep* a point to obtain a line, *scan* the line to define the base, and *raise* the base to conceptualize the volume. A magnitude such as X^3 offers no clue regarding whether it represents an object, and in fact it doesn't. If X is specified to be in kilograms or seconds, clearly the exponent 3 tells us nothing about structural dimensionality (*i.e.*, length, width, and height). If, instead, X is specified to be in meters, it is incumbent upon us to establish first whether this unit represents a distance, a displacement, or the length of the side of an object. From a conceptual point of view, a meter is always the embodiment of motion. A meter

is a relation, a standard defined in terms of *distance traveled*. [11] An extrinsic observer must roll the measuring tape along the sides of a cube and make a series of comparisons to derive its volume. Hence, the meter is never a static unit of length or separation.

b. The second proposal is circular. We must integrate the locations of an object in order to derive the object. The trouble is that this requires *a priori* knowledge of the limits of our integral, which implies that an object necessarily precedes integration. Nevertheless, integrating is the process of aggregating the locations that comprise an object, and, as we just established, the definition of *object* should not be contingent upon motion: the noun of necessity precedes the verb. A more unsettling aspect is that few would confuse a structural entity for its location. A location is an abstract, dimensionless concept depicted with a dimensionless point. [12] Hence, this version of the definition leads to the incongruous notion of a physical, three-dimensional (3D) object comprised of ethereal, zero-dimensional (0D) concepts. If, on the other hand, a point is deemed to be a geometric object [13], we are back to square one.

c. The last and most widely accepted notion of *object* appears to be the best candidate: an object is something we can touch or see. However, this definition is also circular. Words such as something, thing, entity, particle, substance, medium, physical, construct, noun, structure, and body are not definitions but synonyms. 'Something' is the word we are trying to define. A more pertinent objection is that *amenable to touch or sight* is a proof rather than a statement taken at face value. We are challenging the observer to carry out a sensory experiment to determine whether the center of our attention is in fact a physical object. Are undetectable stars at the other side of the universe or neutrinos not objects in the absence of touch or sight? Must two surfaces come into physical contact before we can classify one of them as an object? Does an observer have to place a ruler

parallel to the side of a box for the volume to morph into an object? Should the foregoing definitions be allowed to stand, spacetime and virtual photons could not be classified as objects until the presenter first carries out an experiment to prove this to the audience. The Moon would not be an object until we show the skeptic that we can land on it, and a black hole would not be an object until we demonstrate that this collapsed star emits photons that touch your eyes. We do not test definitions; we test theories. A definition is a proposition embodied in our hypothesis that we agree upon without proof. The see/touch definition stealthily embodies a challenge and, hence, cannot serve as a foundation for our hypothesis.

However, the see/touch criterion has a more fundamental problem. This definition is circular because it invokes another object (*i.e.*, an observer). Isn't an asteroid an object in the absence of gossip or motion? Wasn't Mars an object before life arose on Earth? If an object can be conceived in a hypothetical, static scenario, its definition should be independent of motion, interactions, or the perception of extrinsic observers. The definition should rely solely on intrinsic, inert attributes. The only such innate property that a physical object has is its form:

shape or *form*: inability to blend or become continuous; possessing a continuous surface or boundary; (syn.: discrete, finite).

object: that which has shape.

The verb *has* may mislead careless readers to infer that shape is an extrinsic property imposed by the medium that contours our test object. Isn't a surface, after all, an interface between two objects? The short answer is 'no'! Without a surface we *have* no object to begin with. A surface is a primordial, intrinsic attribute that belongs to the object before it interacts with a hypothetical container. The seeming necessity of a contiguous or encompassing medium is an observer-related phenomenon.

The scientific method

Those who perceive these arguments to be trivial, semantic issues of Philosophy have missed the point. Physics must adhere to the scientific method if this discipline is to be regarded as a science. The scientific method without exception requires definitions and assumptions. It consists of: definitions, hypotheses (illustrations), theory (beliefs), and proof (experiments), in that order.

Definitions. Unless the vocabulary is agreed upon, the proponents must begin by defining the crucial words to be used throughout the presentation. Although definitions may be personal or *ad hoc*, they must be used consistently. The proponents should not be allowed to introduce the word object as *the aggregate of locations of a body* [8] and have it casually change into *that which we can touch* during theory or proof [14].

Hypothesis. It is immaterial whether a hypothesis is derived from observation, equations, experiment, or imagination. [15, 16] Once a hypothesis is formulated, the onus shifts to the prosecutors to make their assumptions about the initial scene clear to a fresh jury. The jurors must visualize the relevant objects, actors, and setting from a bird's-eye perspective before the film is set in motion. A hypothesis is not an untested theory [17], but a still image, a motionless illustration. In fact, a hypothesis is not amenable to testing because it is no more than an assumption made by a proponent. If under rigorous scrutiny, the hypothesis is shown to be self-contradictory or inconsistent, the matter ends there. The advocates should not be allowed to continue to state their beliefs or demonstrate the alleged theory founded upon it. [18]

Theory: Next, the prosecutors proceed to persuade the jury of their version of the events. Referring to the elements established during the hypothesis phase, they disclose their beliefs to the jury. The best

analogy is a movie that begins by focusing on a still image (hypothesis) and then comes alive (theory). Of course, the prosecutors direct this movie as they see fit. They can show angels moving the Earth around the Sun if they wish. But an angel cannot be 'ethereal' in the hypothesis stage [19] and later bump against tables and chairs during theory or proof [20].

Proof: The final step is to re-enact or simulate the explanation offered by the prosecutors to test whether it is at all feasible within the laws of Physics. We test beliefs, not assumptions. If the test is successful, the jurors acquire a certain degree of belief—100% belief constituting certainty—that the events happened in the manner exposed. Skeptics are free to carry out independent confirmations of the allegations in their own laboratories.

The following example underscores the importance of definitions and hypotheses as they relate to the scientific method:

Hypothesis: Let us assume that space and photons are physical objects. [21, 22]

Theory: A photon that reaches your eye from a galaxy eclipsed by the Sun is compelled to swerve from a rectilinear course by the warped space in the vicinity of our star. [23]

Proof: We set up an experiment where a sensitive gyroscope measures frame drag. [24]

If the prosecutor initially defined the word *object* as *something amenable to touch*, any perturbation the gyroscope detects confirms that space is an object. But what have we learned with this exercise? We proved our definition. We proved that space is an object because we were able to touch it. Or did we? Did the gyroscope touch space itself, or did it touch something that exists within space? Can we infer that there is an object such as the Sun by touching a couple of atoms within its center, or is a bird's-eye perspective necessary? If, on the other hand, the definition of object is *that which has shape*, it is

meaningless to carry out any experiment to confirm the definition or the hypothesis. Space must simply meet this requirement if it wants to be regarded as an object *before* we send the gyroscope into orbit.

The hypotheses of relativity and quantum

These two stages of the scientific method—definition and hypothesis—have too often been brushed aside in General Relativity and Quantum Mechanics. The following examples show that this carelessness has led to the amusing notions these theories live with today.

a. *Large-scale structure of spacetime.* The scientific method does not begin with theory or demonstration. It begins with definitions and hypotheses, in that specific order. A cube is a hypothesis. We don't explain or test a cube. We illustrate this still image for the audience before we do anything with it. If we further allege that a cube is an object, we simply need to meet the criterion of the definition of object.

General Relativity proposes a hypothesis called spacetime, an admittedly *unimaginable* [25], four-dimensional object within which all events are staged. (Again, whether space-time was derived from impeccable equations and explains every phenomenon in the universe is irrelevant.) Therefore the audience is denied the luxury of visualizing this unfathomable object before motion is brought into the picture. It could be argued that spacetime is a unique kind of object that is not amenable to visualization. However, Hawking and Turok go out of their way to inform the audience that the primordial Big Bang had the shape of a well-known 3D object**:** *a pea*. [26] Like many of their colleagues, they also refer to our universe with familiar, non-4D adjectives (*e.g.*, *saddle-shaped, spherical, flat*). [27] Indeed, the justification Hawking offers for this unusual architecture is that

we can specify a point within spacetime with four coordinates: longitude, latitude, altitude and time. [28] He stipulates that the surface of Earth is two-*dimensional* because we can locate a point on its surface with two *coordinates*. However, this justification for four-dimensionality is true of a bedroom or a cube as well. A hypothetical point or location within a cube can also be specified with four numbers: longitude, latitude, altitude and time. This makes a cube 'dimensionally' indistinguishable from spacetime. [29] If we can visualize and illustrate a cube, there should be no reason to relieve the hypothesis of space-time from this requirement either. [30]

b. *Finite spacetime*. If space and time had a beginning and are still undergoing an expansion phase [31], spacetime must of necessity be a *finite* object. However, space is defined as *'the infinite extension of field'* and time as a *'continuum'*. [32] Therefore, the prosecutors of General Relativity begin their dissertations with an incongruous hypothesis right off the bat. The jury is asked to consider an assumption consisting of a finite object (spacetime) comprised of an infinite entity (space). The surface of spacetime serves as an endpoint to what by definition can never be discrete (time). Note that these are not trivial semantical issues, but insurmountable barriers to conceptualize the hypothesis.

c. *Infinite spacetime*. To muddle matters further, Ferris [33] and others allege that spacetime is also *unbounded*, a confession that intuitively appears to be self-contradictory. Fortunately, the author goes to great lengths to clarify that the term *unbounded* refers to the quantity of stars we can *count* within spacetime or, in the alternative, the length of time needed to *run* around this globular surface. Indeed, Einstein leaves no doubt with respect to General Relativity's peculiar notion of infinity:

> *What do we wish to express when we say that our space is infinite? Nothing more than that we might* lay *any number whatever of bodies of equal sizes side by side without ever filling space. [34]*

In other words, Einstein is saying that if a mason places a series of tiles on a long floor and gets tired half way down the job, the floor is infinite. Who knows? Perhaps 2 or 3 tiles up ahead we might run up against a wall, but pursuant to his definition we'll never find out. Einstein is not defining structural infinity. He is defining perpetual motion. The words *count*, *run*, and *lay* can at best be qualified as incessant or constant. *Unbounded* and *infinite* are structural attributes. For space to qualify as infinite, it would merely have to be the only object, a hypothesis that is easily demolished. An infinite object ends where you begin!

> *Infinite*: a hypothetical attribute of an object which doesn't have shape. A self-defeating hypothesis.

A proponent wishing to portray space as an object must illustrate its shape for the audience. Success may be attained only if the object being exhibited has well defined boundaries. Conversely, to assume that space is an infinite object is to unwarrantedly contradict the definition of object. But now suppose that space is place, a *where* rather than a *what*. Then it would make as much sense to qualify space as infinite or finite as it would to qualify jumping as green. [35]

d. *Structureless black hole*. A singularity is clearly unimaginable too. A singularity is defined as *a point of infinite curvature and density* [36] whereas, as we just showed, a point depicts a *dimensionless* location. As a result, the audience is presented with an invalid hypothesis before the alleged object is set in motion. [37] Whatever the prosecutor exhibits at the hypothesis stage will have at least width and height. If, on the other hand, we circumvent the

illustration and tolerate this structureless object, we end up at theory with a burlesque cartoon where real astronauts, clocks, and photons are sucked through the perimeter (event horizon) generated by an abstract non-object (singularity). [38]

e. *Dimensionless particle*. A *virtual particle* is defined as an unfathomable object that intermittently oscillates between 0D and 3D. [39] Once again, the audience has trouble understanding the hypothesis, specifically during its 0D phase. At demonstration, we end up half the time with particle physicists accelerating non-particles. [40]

f. *Incongruous photon*. Penrose [41] and Ridley [42] make efforts to illustrate the hypothesis popularly dubbed *the wave-packet*, an incongruous synthesis between a particle and a wave. However, they subsequently fail to explain how this spiraling, *two-dimensional* corkscrew can be stopped by a 3D hand. Bohr [43] bypasses the impossible hypothesis altogether and moves on to explain *how* a photon *behaves*. Duality is a compromise derived from observation. Some experiments appear to show that light *is* a particle. Other experiments direct us to hypothesize that light *is* a transverse wave. However, unbiased application of the scientific method leads to conclude otherwise. The correct interpretation is that some experiments show that light cannot possibly be a transverse wave [45, 46, 47], and others that light cannot possibly be a particle [48, 49]. For the last 400 years we have developed unimpeachable mathematics, but for the wrong hypotheses.

g. *Ethereal ether*. Although not a part of either relativity or quantum, the *aether* [49] is conceptually indistinguishable from the 'seething energy' [50] that many allege pervades or is synonymous with space. The aether will continue to remain an invalid hypothesis until the prosecutor begins by illustrating this exotic medium or substance for the jury.

Conclusion

Ultimately, all topics, events and phenomena of Physics must be traceable to a physical object. Spacetime, singularities, and particles lack the one attribute—shape—that would enable us to classify them as objects and thus accept them as valid hypotheses. The prosecutors of relativity and quantum cannot visualize their own hypotheses, much less share them with the jurors. Such misconceived hypotheses cannot be admitted into Physics, nor can their advocates be allowed to continue to state their beliefs or attempt to prove them until these kinks are ironed out.

Notes and references

[1] force = mass * *acceleration*, energy = mass * (*velocity* of light)^2, and mass is another form of energy. D. Giancoli, *Physics for scientists and engineers*, Prentice Hall, 2000.

[2] I. Newton, *Mathematical Principles of Natural Philosophy*, 3rd ed., Trans. by A. Koyré, I. Cohen, A. Whitman, Harvard University Press (1972).

[3] S. Hawking, *A Brief History of Time*, Bantam. (1988), p. 23. See also M. Visser, "A New Twist," *Science* **282**, 5387 (1998) 249. *http://www.sciencemag.org/cgi/content/summary/282/5387/249* .

[4] Hawking, p. 86. See also F. Baganoff, *et al*., "Rapid X-ray flaring from the direction of the supermassive black hole at the Galactic Centre," *Nature* **413**, (2001) 45-48. *http://www.nature.com/cgi-taf/DynaPage.taf?file=/nature/journal/v413/n6851/abs/413045a0_fs.html* .

[5] black hole: a celestial *object*. *Merriam-Webster's Collegiate Dictionary* (1968). *http://www.m-w.com/cgi-bin/dictionary* .

[6] particle: a portion of matter. *Webster's Revised Unabridged Dictionary (WRUD)*, MICRA (1998). *http://www.dictionary.com* .

[7] volume: occupied space. *The American Heritage Dictionary of the English Language(AHD),* 4th Ed., Houghton Mifflin (2000). *http://www.dictionary.com* .

[8] Hawking, pp. 23-24, 184, 186. See also G. Amelino-Camelia, "Quantum theory's last challenge," *Nature* **408**, (2000) 661-664. *http://www.nature.com/cgi-taf/DynaPage.taf?file=/nature/journal/v389/n6649/full/389337b0_fs.html* .

[9] Spacetime is defined as the aggregate of events or points constituting spacetime. *AHD*. See also *WordNet 1.6 (WN),* Princeton University (1997). *http://www.dictionary.com* .

[10] *AHD. WRUD. WN*. .

[11] B. N. Taylor, Ed., *The International System of Units (SI)*, Sect. 2.1.1.1 *NIST Spec. Publ. 330* (Government Printing Office, Washington, DC, 1991) *http://physics.nist.gov/Document/sp330.pdf.*

[12] R. Douglass, S. Zeldin, *Analytic Geometry*, Ch. 1. McGraw Hill, (1950). M. Shapiro, Ed., *Mathematics Encyclopedia*, Doubleday (1977).

[13] *AHD.*

[14] G. Schilling, "Neutron Stars Imply Relativity's a Drag," *Science* **289**, 5484 (1 Sep 2000), p. 1448. http://www.sciencemag.org/cgi/content/summary/289/5484/1448a .

[15] Spacetime was derived from Einstein's General Relativity paper of 1916. A. Einstein, "Die Grundlage der allgemeinen Relativitaetstheorie," *Ann. d. Physik* **49** (1916) 769-822. .

[16] The contemporary notion of a black hole was formally initiated with Schwarzschild's relativity paper of 1916. K. Schwarzschild, "Über das Gravitationsfeld eines Kugel aus inkompressibler Flüssigkeit nach der Einsteinschen Theorie," *Sitzungsberichte der Königlich Preussischen akademie der Wissenschaften* **1** (1916) 424-434.

[17] Many analysts have this notion that a *hypothesis* is an untested theory. See Hawking, p. 11. D. Miller, "Being an Absolute Skeptic," *Science* **284**, 5420 (4 June 1999) 1625. http://www.sciencemag.org/cgi/content/summary/284/5420/1625 . See also *the scientific method* http://www.encyclopedia.com. However, this definition of *hypothesis* makes no provision for the audience to visualize a still image of the objects, actors and scene before the film is set in motion. Under this version, the prosecutor begins half-way into the case by moving a *photon* before describing or illustrating this alleged object for the jury. If the experiment fails to show the predicted particulate nature of duality, the prosecutor can always change the trivial hypothesis retroactively to a wave so that the theory is consistent with the results. .

[18] Hawking's hypothesis is that the universe started out at 'zero size'. Hawking, pp. 46-50, 123. At the theory stage he is at a loss to explain what physical process enables a lonely, 0D *object* to spontaneously acquire length, width, and height or longitude, latitude and altitude. T. Yulsman, "Give Peas a Chance," *Astronomy* **27**, 9 (Sept. 1999), p. 46.

[19] A particle is defined as *a* body *whose spatial extent ..and structure,* if any*, are irrelevant in a specific problem. AHD*. For example, a muon is regarded to be a pointlike particle (*i.e.*, 0D). A. Hellemans, "Physicists Dream of a Muon Shot," *Science* **279**, 5348 (1998), pp. 169-170. http://www.sciencemag.org/cgi/content/summary/279/5348/169 .

[20] R. Huber, *et al*., "How many-particle interactions develop after ultrafast excitation of an electron-hole plasma," *Nature* **414**, (15 Nov 2001) 286-289. The authors discuss interactions between 0D, point charges.

http://www.nature.com/cgi-taf/DynaPage.taf?file=/nature/journal/v414/n6861/abs/414286a0_fs.html .

[21] P. Dirac, *General Theory of Relativity*, Wiley, (1975), p. 9. M. Tegmark , **"**Measuring Spacetime: From the Big Bang to Black Holes," *Science* **296**, 5572 (2002) 1427-1433. *http://www.sciencemag.org/cgi/content/abstract/296/5572/1427*. .

[22] A photon is defined as a *discrete particle* (*AHD*), or as an indivisible *elementary particle* (*WN*). See also E. Buks, *et al*., "Dephasing in electron interference by a 'which-path' detector," *Nature* **391**, (1998) 871-874. *http://www.nature.com/cgi-taf/DynaPage.taf?file=/nature/journal/v391/n6670/abs/391871a0_fs.html*.

[23] Hawking, p. 34. See also F. Dyson, A. Eddington, and C. Davidson, "A determination of the deflection of light by the sun's gravitational field made during the total eclipse of May 29, 1919," *Mem.Royal Astronomical Society* **62**, (1920) 291.

[24] M. Taber, *et al*., "Results from the First Integrated System Tests of the Gravity Probe B Experiment," The First William Fairbank Meeting, sponsored by ASI, ESA, ISSA, NASA, Rome, Italy, September 10-14, 1990. *http://einstein.stanford.edu/*.

[25] Hawking, p. 24. D. Blair, G. MacNamara, *Ripples on a Cosmic Sea*, Allen & Unwin (1997), pp. 29-30.

[26] T. Yulsman, "Give Peas a Chance," *Astronomy* **27**, 9 (Sept. 1999), pp. 38-46.

[27] W. Kaufmann, *Universe*, Freeman (1991), pp. 566-567.

[28] Hawking, p. 23-24.

[29] The trouble arises because the words dimension and coordinate are used interchangeably in Mathematics. (*AHD*). This bad habit has led mathematicians to extrapolate that a cube is three-*dimensional* because we can specify the location of a point within it with three *coordinates*. However, in Physics, a dimension is conceptually distinct from a coordinate. *Three-dimensional* is an adjective applied to a *single* object that has the structural attribute of facing or pointing simultaneously in three-mutually orthogonal directions (*i.e.*, length, width, and height). Coordinates (longitude, latitude, and altitude), instead, depict orientation and location between *two* objects. Vectors (depth, breadth, and elevation) have to do with the motion of a lone object. By definition, breadth runs at 90^{o} from depth and elevation of the system under study. Facing, pointing, tilt, orientation, and direction are

exclusive, *non-segmentable*, *qualitative* relations of Physics. An object faces or travels in a given direction irrespective of an observer. Magnitude, in contrast, invariably requires that an observer establish a numerical relation (quantitative adverb) between two distinct objects (test object*vs.* preestablished standard). In Mathematics, there are no dimensions, coordinates, or vectors, but *direction-less*, *segmentable number-lines* (*e.g.*, Cartesian *Coordinates* are actually Cartesian *Number-lines*). The only attribute possessed by a number-line is magnitude. The arrowheads do not indicate direction but that numbers increase. The *time* axis in spacetime diagrams tacitly embodies an observer and a relation between the movement of two objects (*e.g.*, hand on a clock *vs*. oscillations of a wave). These two motions are not necessarily perpendicular to each other. Indeed, they need not be rectilinear at all. Time does not run perpendicular to any dimension, coordinate, or vector. The onus shifts to proponents who assert that the arrow of time points, faces, or flows *forward*, to remain silent and point in this physical 'direction' with their index fingers like they would with altitude. Hence, a quantifiable parameter such as *time* is not a dimension, a coordinate, or a vector, but an artificial, direction-less number-line. (Hawking alleges that there is no difference between temporal and spatial coordinates. Hawking, p. 24.).

[30] The cover of *Discover* magazine illustrates the actual size of Alan Guth's spacetime at 10^{-34} seconds. The object portrayed is a red, 2D image of a 3D sphere surrounded by an unspecified white enclosure. B. Lemley, "Guth's Grand Guess," *Discover* **23**, 4 (2002), p. 32. Hawking's instanton is also a 2D projection of a 3D, pea-like object, this time enclosed by an unspecified black medium. T. Yulsman, "Give Peas a Chance," *Astronomy* **27**, 9 (Sept. 1999), p. 43. .

[31] Hawking, p. 128. See also C. Hogan, "The Beginning of Time," *Science* **295**, 5563 (2002) 2223-2225.

[32] *AHD. WRUD.* .

[33] Ferris argues that General Relativity solved the ageless problem of whether the universe is finite or infinite by proposing that it is both. Ferris, T., *Coming of Age in the Milky Way*, William Morrow (1988), pp. 200-202. See also Hawking, p. 47.

[34] A. Einstein, "Geometry and Experience," lecture to the Prussian Academy of Science, January 27, 1921.

[35] Under my proposal, we inhabit a simple, binary universe comprised of matter and space, much like the active 1 and the passive positional notation 0 of binary logic. If matter is that which has shape, space is that which doesn't. Space is not a thing, but a place. However, we should be careful to distinguish between artificial, shapeless concepts such as love and the place I call space. Space served as backdrop to matter before life arose on Earth.
space: a place; that which doesn't have shape, surface, or perimeter. (syn.: nothing, discontinuity.).

[36] Hawking, p. 46, 186. A singularity is a dimensionless *point*. *AHD*. .

[37] Khanna, G., *et al*., "Inspiraling Black Holes: The Close Limit," *Physical Review Letters* **83**, 3581-3584 (1999). The authors discuss the dynamics of black hole collision.
http://ojps.aip.org/getabs/servlet/GetabsServlet?prog=normal&id=PRLTAO000083000018003581000001&idtype=cvips&gifs=Yes .

[38] W. Cash, *et al*., "Laboratory detection of X-ray fringes with a grazing-incidence interferometer," *Nature* **407**, (2000) 160-162.
http://www.nature.com/cgi-taf/DynaPage.taf?file=/nature/journal/v407/n6801/abs/407160a0_fs.html.

[39] A. Watson, Exploring the Proton Sea, *Science* **283**, 5401 (1999) 472-474.
http://www.sciencemag.org/cgi/content/summary/283/5401/472 . G. Taubes, New Exotic Particle Points to Double Life for Gluons, *Science* **277**, 5332 (1997) 1609.
http://www.sciencemag.org/cgi/content/summary/277/5332/1609.
Indeterminacy allegedly enables virtual particles to exist temporarily. *AHD*.
http://www.dictionary.com/search?q=virtual%20particle.

[40] Particle physicists allege that they have created particles from nothing. S. P. Gavrilov and D. M. Gitman, "Vacuum instability in external fields," *Phys. Rev*. D 53, 12, (1996) 7162–7175.
http://cornell.mirror.aps.org/abstract/PRD/v53/i12/p7162_1. See also D. Jones, "Watch this space," *Nature* 396, (03 Dec 1998) 417.
http://www.nature.com/cgi-taf/DynaPage.taf?file=/nature/journal/v396/n6710/full/396417b0_fs.html.
The trouble is that these theorists bypass the definition stage of the scientific method. The scientific method requires that the proponent begin by defining *something* and *nothing* before such beliefs are even considered.

[41] R. Penrose, *The Emperor's New Mind*, Oxford University Press, (1999), p. 249.

[42] B. Ridley, *Time, space and things*, Cambridge University Press (1984), p. 12.

[43] N. Bohr, "Can quantum-mechanical description of physical reality be considered complete?" *Phys.Rev*. **48** (1935) 696.

[44] Consensus is that the photoelectric effect demonstrates that light cannot possibly be a wave. A. Einstein, *Ann. d. Physik* **17** (1905) 132 [English translation A. Arons, M. Peppard, *Am. J. Phys.* **33** (1965)].

[45] X-ray scattering also demonstrates that light cannot be a wave. A. Compton, *Philos. Mag* **45**, (1923) 1121.

[46] A wave is a *disturbance* (an action) and thus an invalid hypothesis. *AHD*.

[47] The double slit experiment conclusively shows that light cannot possibly be a particle. T. Young, *Phil. Trans. Roy. Soc.*, London xcii (1802) 12, 387.

[48] The particle hypothesis requires that light travel faster in denser media. This has resolutely been shown to be untrue. L. Foucault, *Compt. Rend. Acad. Sci.* **30** (1850) 551.

[49] A. Fresnel, *Oeuvres* **2**, 261, 479. A. Michelson, "The Relative Motion of the Earth and the Luminiferous Ether," *Am. J. of Science* **22** (1881), 120-129.

[50] S. Glashow, *The Charm of Physics*, American Institute of Physics, (1991). R. Villard, R. Lloyd, "Astrophysics Challenged By Dark Energy Finding," SPACE.com, April 10, 2001. *http://www.space.com/scienceastronomy/generalscience/darkenergy_folo_010410.html* .