Einstein as Ghost Buster

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March 22, 2020

Abstract

In 1939, a rather cowardly lion confessed to believing in spooks. Well, Einstein wasn't having it. He had long before that declared victory over the former ghosts of absolute space and time, that had of old lurked in the background of theoretical physics.

1 Introduction

To the modern physicist, the special and general theories of relativity are wonderful ways to found modern physics, the former for particle physics (the Standard Model) and the latter for cosmology. But to Einstein, those are merely the practical outcomes of his relativity research program. To him, the relativist is first of all a Ghost Buster!

Einstein put it this way:

> The ghosts of absolute motion and the inertial CS [coordinate systems] can be expelled from physics and a new relativistic physics built.
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> — Found in: *The Evolution of Physics*, p. 222.

And also:

> The equations from the new theory are, from the formal point of view, more complicated, but their assumptions are, from the point of view fundamental principles, much simpler. The two frightening ghosts, absolute time and an inertial system, have disappeared.
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> — Found in: *The Evolution of Physics*, p. 238.

Einstein used the metaphor of a 'ghost' to mean what, exactly? I believe he meant that a theoretically conceived entity that can influence material point masses, yet not be reciprocally affected by them:

> In Newton's equations of motion, the concept of acceleration plays a fundamental part, which cannot be defined by the temporally variable intervals between points alone. Newton's acceleration is only

> conceivable or definable in relation to space as a whole. Thus to the geometrical reality of the concept of space a new inertia-determining function of space was added. When Newton described space as absolute, he no doubt meant this absolute significance of space, which made it necessary for him to attribute to it a quite definite state of motion, which did not appear to be fully determined by the phenomena of mechanics. This space was conceived as being absolute in another sense also; its inertia-determining effect was conceived as autonomous, i.e., not to be influenced by any physical circumstance whatever; it affected masses, but nothing affected it.
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> — Found in: "The problem of space, ether, and the field in physics," *Ideas and Opinions*, pp. 279–280.

Let's consider an analogy. Bob and Alice each climb onto their assigned trampolines. Bob finds that his normal trampoline reacts to his being on it and moving about on it. Whereas, Alice finds that her weird trampoline doesn't move at all from her moving about on it. Bob jounces his knees and finds himself raised above the mat surface. But nothing Alice can do will move the trampoline mat at all. Yet, quite suddenly, without the surface moving at all, she finds herself lifted a foot off the canvas. By some magic, it seems, the mat can influence her state of motion, yet she can do nothing to influence the state of motion of the trampoline mat.

2 The Evidence

Today, everyone knows about

$$E = mc^2 \,, \tag{1}$$

but to Einstein, that equation was a mere practical result of his research program, not at the heart of the goal he pursued until his death in 1955. Einstein saw himself as the epistemological equivalent of a ghost buster, out to rid physics of its reliance on absolute spaces of any kind, and unify what remained.

> The problem of formulating physical laws for every coordinate system was solved by the so-called general relativity theory; the previous theory, applying only to inertial systems, is called the special relativity theory. The two theories cannot, of course, contradict each other, since we must always include the old laws of the special relativity theory in the general laws for an inertial system. But just as the inertial coordinate system was previously the only one for which physical laws were formulated, so now it will form the special limiting case, as all coordinating systems moving arbitrarily, relative to each other, are permissible.
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> This is the program for the general theory of relativity. But in sketching the way in which it was accomplished we must be even vaguer than we have been so far. New difficulties arising in the

development of science force our theory to become more and more abstract. Unexpected adventures still await us. But our final aim is always a better understanding of reality. Links are added to the chain of logic connecting theory and observation. To clear the way leading from theory to experiment of unnecessary and artificial assumptions, to embrace an ever-wider region of facts, we must make the chain long and longer. The simpler and more fundamental become, the more intricate is our mathematical tool of reasoning; the way from theory to observation becomes longer, more subtle, and more complicated. Although it sounds paradoxical, we could say: Modern physics is simpler than the old physics and seems, therefore, more difficult and intricate. The simpler our picture of the external world and the more facts it embraces the stronger it reflects in our minds the harmony of the universe.

Our new idea is simple: to build a physics valid for all coordinate systems. Its fulfillment brings formal complications and forces us to use mathematical tools different from those so far employed in physics. We shall show here only the connection between the fulfillment of this program and the two principal problems: gravitation and geometry.

— Found in: *The Evolution of Physics*, Einstein & Infeld pp. 212–214.

Einstein referred to other programs of research in physics. First Newton's:

According to Newton's system, physical reality is characterized by the concepts of space, time, material point, and force (reciprocal action of material points). ... In order to put his system into mathematical form at all, Newton had to devise the concept of differential quotients and propound the laws of motion in the form of total differential equations.

— Found in: "Maxwell's influence on the evolution of the idea of physical reality," *Ideas and Opinions*, Einstein, pp. 267–268.

Referring to Newton's programmatic biases, Einstein said:

It is not surprising that Newton would not listen to a wave theory of light; for such a theory was most unsuited to his theoretical foundation.

— Found in: "The fundaments of theoretical physics," *Ideas and Opinions*, p. 325.

According to the "Maxwellian view":

I am still inclined to the view that physicists will not in the long run content themselves with that sort of indirect description of the

> real, even if the theory can eventually be adapted to the postulate of general relativity in a satisfactory manner. We shall then, I feel sure, have to return to the attempt to carry out the program which may be described properly as the Maxwellian—namely, the description of physical reality in terms of fields which satisfy partial differential equations without singularities.
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> — Found in: "Maxwell's influence on the evolution of the idea of physical reality," *Ideas and Opinions*, p. 270 (first published in 1931).

Einstein introduced the notion of 'ghost busting' which means that every epistemological gap in physics will be exploited to remove some ghost that "human intuition has preferred rather than the symmetry of the equivalence of all reference frames." The ghosts that Einstein busted were the ghost of absolute rest embodied in the luminiferous ether. The ghost of the inertial reference frame. The ghostly action at a distance. And, finally, the ghost of absolute time.

In his 1905 paper "On the electrodynamics of moving bodies," (p. 1), Einstein addressed this first ghost:

> Examples of this sort, together with the unsuccessful attempts to discover any motion of the earth relatively to the 'light medium', suggest that phenomena of electrodynamics as well as of mechanics possess no properties corresponding to the idea of absolute rest.

To be clear on this, a space of absolute rest would presumably assign to all mass particles an absolute universal velocity.

What this means is that any use of the idea of "absolute rest" is strictly forbidden in SR as a modeling stratagem because of this stated programmatic bias. So where does this bias of Einstein's come from? He tells us again from his 1905 paper: "The observable phenomena here depends only on the relative motion of conductor and magnet..." — which is an observable! He tells us a bit more in his paper on general relativity, after he presents the thought experiment of two fluid bodies, one "rotating" the other not. An observer will notice a difference in the shape of one to the other, and Einstein wanted to know the observable "cause" of this difference.

> What is the reason for this difference in the two bodies? No answer can be admitted as epistemologically satisfactory, unless the reason given is an observable fact of experience. The law of causality has not the significance of a statement as to the world of experience, except when observable facts ultimately appear as causes and effects.
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> — Found in: "The Foundation of the General Theory of Relativity," Einstein, *The Principle of Relativity*, Reprinted by Dover, pp. 148–149.

In other words, he's claiming that an appeal to the ultimate cause being some invisible, ghostly absolute inertial frame is unepistemological, and in his pro-

grammatic biases disallowed. Einstein is not pontificating the "true" epistemology for everyone, but rather is just revealing the epistemology that he has accepted for his own research program.

But Einstein has a method of exploiting these epistemological ghosts, which is prescribed by his biases as well. In the lacuna of an epistemological gap that has as an "explanation" some metaphysical element, one is free to re-explain the phenomena in any manner possible, and it is preferred in relativity to always use such opportunities to widen the range of the equivalence of reference frames for which the so-called laws of physics will apply within.

As a result of all these biases, Einstein claims that it is unwarranted in physics to continue to assume the existence – formal or otherwise – of some ghostly Absolute inertial reference frame with respect to which Absolute acceleration is meaningful to Nature. And then, with this prohibition against the use of a model of Absolute space defining an absolute acceleration in Einstein's program, Einstein was free to complete his unification scheme that places all reference frames on an equivalent status with respect to the description of phenomena by means of physical laws — i.e., by means of mathematical constraints on the observables of physics in conformance to some a priori chosen set of preferred frames of reference. Einstein says:

> Physical concepts are free creations of the human mind, and are not, however it may seem, uniquely determined by the external world.
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> — Found in: *The Evolution of Physics*, p. 31.

The "freeness" of physical theories requires one to make programmatic choices to fix some philosophically free "gauges," we might say, or "soft constraints." Otherwise chaos reigns.

Perhaps the most profound bias in a research program in physics is how one defines the purpose of science. Einstein put it this way:

> Science is the attempt to make the chaotic diversity of our sense experience correspond to a logically uniform system of thought.
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> — Found in: "The fundaments of theoretical physics," *Ideas and Opinions*, p. 323.

He goes on to say,

> By this last [by the scientific way of forming concepts using logical economy] we mean the effort to reduce all concepts and correlations to as few as possible logically independent basic concepts and axioms.
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> — Found in: "The fundaments of theoretical physics," *Ideas and Opinions*, p. 324.

But is this really a bias? Indeed it is. For if one decides that physics should first of all invent mechanical models by which to 'explain' each phenomenon, then one may have to invent a variety of material things for each phenomenon, each, perhaps, being very different than the others. But if one places unity

above easy-to-understand mechanical models, then one may be able to found physics on fewer assumptions, but at the cost of longer chains of deductions and less intuitive conceptual models. This latter path is what Einstein chose, and he has been criticized for it by skeptics and debunkers ever since.

On the same page he goes on to say:

> On the other hand, from the very beginning there has always been present the attempt to find a unifying theoretical basis for all these single sciences, consisting of a minimum of concepts and fundamental relationships, from which all the concepts and relationships of the single disciplines might be derived by logical process. This is what we mean by a search for a foundation of the whole of physics. The confident belief that this ultimate goal may be reached is the chief source of the passionate devotion which has always animated the researcher. It is in this sense that the following observations are devoted to the foundations of physics.

Einstein was not content to settle for having established the equivalence of all inertial reference frames for the formulation of the laws of physics. He want then to find a way to generalize the equivalence to all reference frames, and to include gravitational phenomena as well.

> When by the special theory of relativity I had arrived at the equivalence of so-called inertial systems for the formulation of natural laws (1905), the question of whether there was not a further equivalence of coordinate systems followed naturally, to say the least of it. To put it another way, if only a relative meaning can be [empirically] attached to the concept of velocity, ought we nevertheless to persevere in treating acceleration as an absolute concept? From the purely kinematic point of view there was no doubt about the relativity of all motions whatever; but physically speaking, the inertial system seemed to occupy a privileged position, which made use of coordinate systems moving in other ways appear artificial.
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> — Appeared in: *Albert Einstein's General Relativity*, "Notes on the origin of the general theory of relativity," Crown Publication, New York, 1979, p. 48.

And also,

> The conclusion is obvious that the arbitrarily moved frame of reference is equivalent to any other for the formulation of the laws of Nature, there that are thus no physically preferred states of motion at all in respect of regions of finite extension (general relativity principle).
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> — Found in: *Albert Einstein's General Relativity*, "Fundamental ideas and problems of the theory of relativity," Crown Publication, New York, 1979, p. 54.)

So, if the 'rotating' sphere did not rotate relative to some invisible reference frame, then to what frame?

> There is yet another factor underlying the evolution of the general theory of relativity. As Ernst Mach insistently pointed out, the Newtonian theory is unsatisfactory in the following respect: If one considers motion from the purely descriptive, not from the causal, point of view, it only exists as relative motion of things with respect to one another [empirically speaking]. But the acceleration which figures in Newton's equations of motion is unintelligible if one starts with the concept of [complete] relative motion. It compelled Newton to invent a physical space in relation to which acceleration is supposed to exist. This introduction ad hoc of the concept of absolute space, while logically unexceptionable, nevertheless seems unsatisfactory. Hence Mach's attempt to alter the mechanical equations in such a way that the inertia is trace back to relative motion on their part not as against absolute space but as against the totality of other ponderable bodies. In the state of knowledge then existing, his attempt was bound to fail.
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> — Found in: *Albert Einstein's General Relativity*, "On the theory of relativity," Crown Publication, New York, 1979, p. 60.

> We turn now to the second stage in the development of the theory of relativity, the so-called general theory of relativity. This theory also starts from a fact of experience which till then had received no satisfactory interpretation: the equality of inertial and gravitational mass, or, in other words, the fact known since the days of Galileo and Newton that all bodies fall with equal acceleration in the earth's gravitational field. The theory uses a special theory as its basis and at the same time modifies it: the recognition that there is no state of motion whatever that is physically privileged—that is, that not only velocity but also acceleration are without absolute significance—forms the starting point of the theory.
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> — Found in: *Albert Einstein's General Relativity*, "Field theories: old and new," Crown Publication, New York, 1979, pp. 67–68.)

In the end, Einstein was able to declare victory!

> The victory over the concept of absolute space or over that of the inertial system became possible only because the concept of the material object was gradually replaced as the fundamental concept of physics by that of the field. Under the influence of the ideas of Faraday and Maxwell the notion developed that the whole of physical reality could perhaps be represented as a field whose components depend on four space-time parameters. If the laws of this field are in general covariant, that is, are not dependent on a particular choice

of coordinate system, then the introduction of an independent (absolute) space is no longer necessary.

— Found in: *Albert Einstein's General Relativity*, "Concept of space," Crown Publication, New York, 1979, p. 171.)

3 Conclusion

The Einstein debunkers who charge Einstein with replacing theories they can 'understand', in terms of cause and effect, with just nonsense mathematics, don't fully appreciate what Einstein actually accomplished. The 'frightening ghosts', that classical physics had left unchallenged, actually explained nothing in terms of cause and effect, though they carried with them the verisimilitude of such.

Einstein exposed these absolute spaces for the charlatans that they are, and in their places he constructed theories that were less pretentious than those with absolute spaces. And, by definition, such replacement theories would have to be 'relativistic' in nature. So, eventually, they got called such.