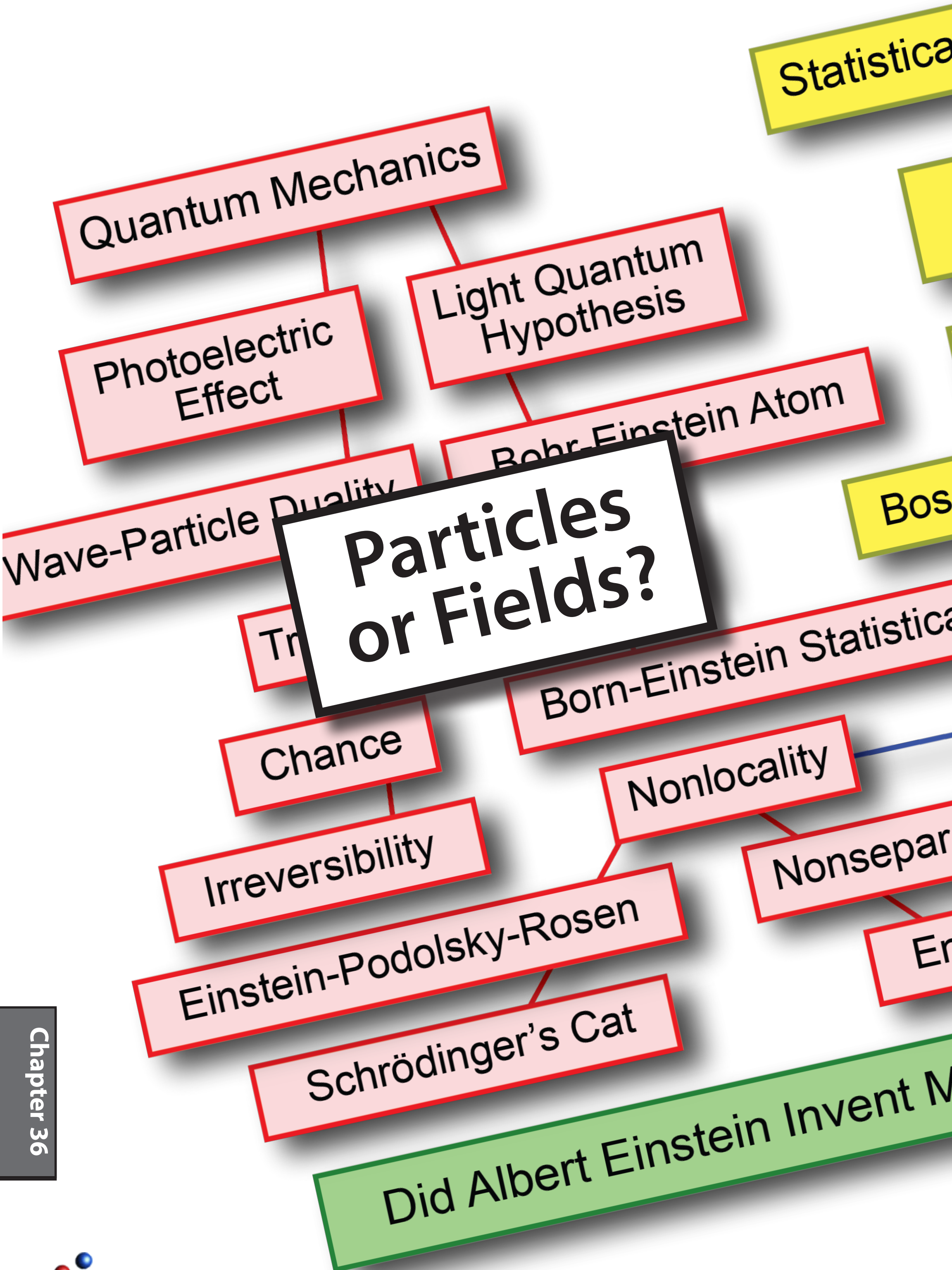
Particles or Fields?



Chapter 36

Particles or Fields?

Einstein in his later years grew quite pessimistic about the possibilities for deterministic continuous field theories, by comparison with indeterministic and statistical discontinuous particle theories like those of quantum mechanics.

To Leopold Infeld he wrote in 1941,

> "I tend more and more to the opinion that one cannot come further with a continuum theory." [1]

Einstein's deeply believed that any physical theory must be based on a continuous field. For Einstein, physical objects must be described by continuous functions of field variables in four-dimensional space-time coordinates. In quantum field theory (QFT), particles are functions of (singularities in) these fields. In quantum electrodynamics (QED), fields are merely properties of aggregated particles. Which then are the more fundamental?

It appears to be particles, especially today when the last fundamental particle predicted by the standard theory (the Higgs boson) has been found. Einstein suspected that his dream of a unified field theory may not be possible.

In his 1949 autobiography for his volume in Paul Schilpp's *Library of Living Philosophers*, Einstein asked about the theoretical foundation of physics in the future, "Will it be a field theory [or] will it be a statistical [particles] theory?"

> "Before I enter upon the question of the completion of the general theory of relativity, I must take a stand with reference to the most successful physical theory of our period, viz., the statistical quantum theory which, about twenty-five years ago, took on a consistent logical form (Schrödinger, Heisenberg, Dirac, Born). This is the only theory at present which permits a unitary grasp of experiences concerning the quantum character of micro-mechanical events. This theory, on the one hand, and the theory of relativity on the other, are both considered correct in a certain sense, although their combination has resisted all efforts up to now. This is probably the

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reason why among contemporary theoretical physicists there exist entirely differing opinions concerning the question as to how the theoretical foundation of the physics of the future will appear. Will it be a field theory; will it be in essence a statistical theory? I shall briefly indicate my own thoughts on this point.

"Physics is an attempt conceptually to grasp reality as it is thought independently of its being observed. In this sense one speaks of "physical reality." In pre-quantum physics there was no doubt as to how this was to be understood. In Newton's theory reality was determined by a material point in space and time; in Maxwell's theory, by the field in space and time. In quantum mechanics it is not so easily seen. If one asks: does a ψ-function of the quantum theory represent a real factual situation in the same sense in which this is the case of a material system of points or of an electromagnetic field, one hesitates to reply with a simple "yes" or "no"} why? What the ψ-function (at a definite time) asserts, is this: What is the probability for finding a definite physical magnitude q (or p) in a definitely given interval, if I measure it at time t? The probability is here to be viewed as an empirically determinable, and therefore certainly as a "real" quantity which I may determine if I create the same ψ-function very often and perform a q measurement each time.

"But what about the single measured value of q? Did the respective individual system have this q-value even before the measurement? To this question there is no definite answer within the framework of the [existing] theory, since the measurement is a process which implies a finite disturbance of the system from the outside; it would therefore be thinkable that the system obtains a definite numerical value for q (or p), i.e., the measured numerical value, only through the measurement itself."

Einstein is asking the key question: Is there but one possible measurement before the actual measurement? See chapter 26.

In 1954 Einstein wrote his friend Michele Besso to express his lost hopes for a continuous field theory like that of electromagnetism or gravitation,

"I consider it quite possible that physics cannot be based on

> the field concept, i.e:, on continuous structures. In that case, nothing remains of my entire castle in the air, gravitation theory included, [and of] the rest of modern physics."[2]

The fifth edition of Einstein's *The Meaning of Relativity* included a new appendix on his field theory of gravitation. In the final paragraphs of this work, his last, published posthumously in 1956, Einstein wrote:

> "Is it conceivable that a field theory permits one to understand the atomistic and quantum structure of reality ? Almost everybody will answer this question with "no"...
>
> "One can give good reasons why reality cannot at all be represented by a continuous field. From the quantum phenomena it appears to follow with certainty that a finite system of finite energy can be completely described by a finite set of numbers [quantum numbers]. This does not seem to be in accordance with a continuum theory, and must lead to an attempt to find a purely algebraic theory for the description of reality. But nobody knows how to obtain the basis of such a theory."[3]

A Universe of Particles?

Einstein here is not denying the possibility of an infinite universe, although in the last few decades of his life the majority view of astronomers was that the curvature of space was positive, that there was an excess of gravitational binding energy over the measured kinetic energy of the receding galaxies.

When Einstein first formullated his general theory, he saw that a universe containing matter could not be stable against the gravitational force. Like a ball thrown into the air, the universe should be expanding (ball on the way up) or contracting. Einstein visited astronomers (source needed) and asked them which was the case. They told Einstein the stars were "fixed" in the heavens, like the ball sitting up in the air despite gravity.

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2 Pais, 1982, p.467

3 Einstein, 1956, pp.165-66

The favored cosmological model until the early 1950's was an unbounded but finite space, inside which all paths ultimately curved back on themselves.

In fact, observations had been made ten years before Einstein's death, by Walter Baade, a German national working in the United States during World War II. Baade was prevented from working in the war effort, at the same time other scientists were required or volunteered to do so, leaving telescope time at the great 100-inch refracting telescope on Mount Wilson to Baade.

Wartime added a great advantage to Baade's efforts. Light pollution in the Los Angeles area was greatly lessened by grayouts (partial blackouts) to hide targets from enemy submarines. Baade was able to resolve individual stars in the Andromeda galaxy. He saw two different types of Cepheid variable stars, whose absolute luminosities had been discovered to be a function of their period of variation by Harvard astronomer Henrietta Swan Leavitt in 1908.

In 1929, Edwin Hubble used Leavitt's work on Cepheids in the Large Magellanic Cloud to calculate the distance to Andromeda and to dozens of other nearby galaxies. Red-shift measurements by Hubble's colleague Vesto Slipher established the linear velocity-distance relationship that proved the universe is expanding, now known as the Hubble law.

Space and Time don't exist - as substances. They are relations, a means of quantifying with infinitesimal precision the positions and momenta, the equations of motion, for discrete particles, etc. Just metaphysics. Hume said we spread relations like space and time over reality. But space and time give us ex

But his third relation - resemblance, is a relation

Cosmology Without Fields?