



## EINSTEIN, 1905: FICTION BECOMES REALITY

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by *Alberto G. Rojo*

Great creative acts dissolve the boundaries between disciplines. The monumental contributions of Einstein's *annus mirabilis*, which we celebrate this year, emerged from a convergence of art and science and from, what Coleridge called, the "suspension of disbelief." When we cry at Valjean's death in *Les Misérables* or are paralyzed by a scene in *Dracula* it is because we yield to the rules of an illusory world and accept it as real. In developing his theories, Einstein proceeded to a large extent like an artist, incorporating aesthetic elements into his line of reasoning, capturing ideas that were considered mathematical fictions by prominent scientists of his time (Poincaré, Lorentz, Planck) and relocating what was imaginary into the real world.

In 1905, Einstein published a series of papers, in the well-known German journal *Naturwissenschaft*, which embody the fruitful encounter of fiction and reality, art and science. The title of his first paper, appearing in March, is "On a Heuristic Viewpoint Concerning the Production and Transformation of Light." Heuristic refers to the art of invention and derives from *heuriskein*, the past tense of which is the proverbial "eureka." In this study (the only one he considered revolutionary and for which he received the Nobel Prize in 1921), Einstein proposed that light has a granular structure, the so-called "quanta," which would later be called photons. According to Einstein, light is emitted or absorbed in fixed quantities, just as trucks

come out of factories, whole, and arrive at truck dealerships one by one, and not in fractions of trucks.

The idea of dividing the energy of light into fixed amounts, or quanta, is not original with Einstein. In 1900, Max Planck proposed the division of energy into quanta and arrived at a formula in perfect agreement with the distribution of colors emitted by an incandescent body. Planck, however, failed to attribute a clear physical interpretation to the quanta and in an “act of desperation” he tried unsuccessfully to reconcile them with the physical theories of the nineteenth century. In his Nobel Prize lecture of 1918, Planck said, in a somewhat confessional tone:

The failure of all attempts to bridge this gap soon placed one before the dilemma: either the quantum of action was a *fictional quantity*, then the whole deduction of the radiation law was *illusory* and represented nothing more than an empty non-significant play on formulae, or the derivation of the radiation law was based on a sound physical conception. [ . . . ] Experiment has decided for the second alternative. [ . . . ] The first impact in this field was made by A. Einstein. (Italics added)

With notable conceptual refinement, Einstein accepts the quanta, which existed in the form of mathematical fictions, as new members of the fauna of the physical world.

The second paper, published in June, deals with the theory of relativity, the same one that eventually brought Einstein rock-star fame. The first sentence of the essay makes an aesthetic observation:

It is known that Maxwell’s electrodynamics, as usually understood at the present time, when applied to moving bodies, leads to *asymmetries* which do not appear to be inherent in the phenomena. (Italics added)

Einstein discusses the meaning of this asymmetry with an example of electromagnetism. He observes that a magnet in motion relative to a wire loop produces an electrical current in the wire. According to Maxwell’s theory, different equations

apply when the magnet moves and the wire is stationary and in the contrary case. In one case, the magnet is moving with respect to the ether (a universal static substance that acts as the medium for transmission of light) and in the other, the magnet is at rest with respect to the ether. This asymmetry was unacceptable to Einstein. If the current is the same in both cases, then one is looking at the same phenomenon from different perspectives, from different reference frames, thus making the idea of an ether superfluous.

From this starting point, as simple as it is audacious, Einstein leads us through a path of impeccable logic that culminates in the notion that time, the ticking of a wristwatch, is not an absolute phenomenon. Two people riding bicycles illustrate the point. If Alice and Mary have identical wristwatches and Alice passes by riding her bike close to Mary, Alice perceives that her watch runs faster than Mary's and Mary perceives that her watch runs faster than Alice's. How much faster? Einstein predicts the difference, which is only appreciable if Alice and Mary are moving with respect to each other at speeds close to that of light.

It is remarkable that these equations existed before Einstein's work, and this returns us to the crossroad between fiction and reality. In 1895, the Dutch physicist Hendrik A. Lorentz, in order to explain some experiments by Michelson and Morley wrote a set of equations (identical to Einstein's) in which time appeared as a mathematical variable that depended on velocity and position. Lorentz distinguished between a "true time" (the one measured by a clock at rest) and "local time" (the one dependent on the location of an event). The crucial point is that Lorentz considered the local time a mere *mathematical fiction* used to simplify an equation. Einstein accepts that fiction as real and incorporates it into his relativistic universe.

Einstein's third paper, written in September, contains the most famous equation in the history of science: Energy equals the mass (the amount of matter) multiplied by the velocity of light squared. The equal sign means that energy can be con-

verted into matter and matter into energy, a concept unthinkable before Einstein. A simple example from the kitchen demonstrates the physics involved. By heating water we are increasing its energy and therefore, according to the celebrated equation, we increase its mass—a hot tea pot is heavier than a cold one. This effect is imperceptible, but its impact is huge. Less than a gram of matter converted into energy was enough to create the monstrous pressure, and a temperature of millions of degrees, that devastated Hiroshima. Einstein was not the first to write this equation. In 1900, Henri Poincaré published a paper in the *Archive Néerlandaises des Sciences Exactes et Naturelles* in which he considered light as a “fictitious fluid” (*fluide fictif*) with a mass and energy such that. The brilliance of Einstein, in 1905, is that he accepts this equation as belonging to the real world, revealing an equivalence that Poincaré considered only fictitious.

In the three most important papers of Einstein’s wonderful year, reality and fiction converge in a way without precedents in the history of knowledge. This confluence is possible when imagination erases the boundaries between disciplines like science, philosophy and art, in the search for truth. Why, then, are aesthetic criteria, like symmetry and simplicity, qualities of correct theories? That is a great mystery. The resolution of the question may be found in Keats’s *Ode on a Grecian Urn*: ‘Beauty is truth, truth beauty, that is all Ye know on Earth, and all ye need to know.’