PHYSICS AND POETRY

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My favorite metaphors come from physicists. Let me count a few. One is the Universe as a book, certainly popular in the Middle Ages, but perfected by Galileo Galilei, who, in *Il saggiatore* specifies its alphabet: "It is written in a mathematical language, and its characters are triangles, circles, and other geometrical figures."[1] The second is the arrow of time, a metaphor coined by Arthur Eddington in his *The Nature of the Physical World*, to describe the "one-way direction" in which things progress and evolve, the curious asymmetry of a macroscopic world whose microscopic inner workings all obey time-symmetric laws. In the relativistic four–dimensional map of the world, space and time are to some extent interchangeable, but if one were to draw that map in "a solid block of paper," time would evolve in a preferential way. Therefore, Eddington chooses "the phrase 'time's arrow' to express this one-way property of time which has no analogue in space." The third comes from Werner Heisenberg, the scientist regarded by many as the least poetic: "Light and matter are both single entities, and the apparent duality arises in the limitations of our language." The line, perhaps not strictly a metaphor, is from the introduction to *The Physical Principles of Quantum Theory*, where he presents the details of a new Physics with an almost

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[1] See the delightful essay "The Book of Nature in Galileo," in *Why Read the Classics*, by Italo Calvino.

dictatorial mathematical rigor, deprived—according to widespread consensus—of all aesthetic content. I chose it because it points to the core of the intersection between poetry and science: the limitation of language. Language, with a finite number of symbols and permutations, imposes bounds for expressing the architecture of an invisible world for which it was not conceived. Poetry and metaphor expand those boundaries and interpolate the continuous, analog space in between the discrete, digital map of language. If, with Wittgenstein, we believe that "The limits of my language are the limits of my world," it is through poetry and metaphor that those limits are stretched and even dissolved. I wish to present here some examples in which the poetic imagination anticipates and inspires scientific discoveries, initial artifices of the poetic imagination that were later anthologized into a scientific synthesis of reality.

Beauty, the aesthetic criterion, the search for a correspondence between natural laws and a pre-established order, prior even to experimentation, is a guiding principle in many scientific advances. Claussius, Einstein, Dirac, Weyl, and De Broglie deciphered complex clues of the Universe, pursuing a horizon of symmetry and simplicity, rather than the explanation of unexplained experiments. Thus they unfolded the precise fabric of a coherent tapestry, a map of reality implicit in an intricate skein of metaphors, literary intuitions and fantastic extrapolations of reality. "You see, my son, here time turns into space," says Wagner in *Parsifal.* And Edgar Allan Poe, in *Eureka, a Poem in Prose* (1848), proposes the solution accepted today for the so-called Olbers' paradox: if the universe is of infinite extent and the stars are distributed throughout the universe, then we should see a star in any direction and the night sky should be bright. However, it is dark. Why? Poe writes that "The only mode, therefore, in which we could comprehend the voids which our telescopes find in innumerable directions, would be by supposing the distance of the invisible background so immense that no ray from it has yet been able to reach us at all." Many years later, Ernesto Cardenal would cite

him in "The Music of Spheres": "but night is dark and the universe neither infinite nor eternal."

Heisenberg's works, on the other hand, don't seem to emerge from that tradition. Steven Weinberg emphasizes this feature in *Dreams of a Final Theory*. Heisenberg does not resort to visualizations or extrapolations from prior intuitions but rather proceeds, says Weinberg, like a magician ''who does not seem to be reasoning at all but who jumps over all intermediate steps to a new insight about nature.'' This is why I'm fascinated by Heisenberg's allusion to a limitation of language in referring to an apparent physical duality. Poetry is precisely the insisting attempts to prolong the reach of our intelligence, the search of micro-revelations, the intention to express the inexpressible.

The *Divine Comedy* anticipates two great ideas in Physics: Galilean relativity (the unification of the state of rest and the state of motion), and the curvature of space. Dante's cosmology is geometrically complex, and actually seems to be a so-called "closed" universe, a version that emerges as one of the solutions of Einstein's general relativity theory[2] (Peterson 1031–1035). In the *Paradiso*, Dante implicitly approaches a question posed by every child: does the universe have an "edge"? He describes his ascent, sphere by sphere, to the Primum Mobile, beyond which are the Empyrean, home of God and the angels. Each semi-universe, at both sides of the Primum Mobile, is made of nine concentric spheres that first increase in diameter and then decrease. Dante is confused about this and Beatrice explains it to him in Canto 28. But let's think first of the curvature of the surface of the Earth, and imagine moving from the North Pole to the South Pole, a journey during which we will cross concentric circles (the parallels) of increasing size until we reach the Equator; from then on the circles start decreasing in size. Dante's world is, however, three-dimensional, and rather than circles he crosses spheres.

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[2] "Dante and the 3-sphere". Mark A. Peterson, *American Journal of Physics,* **47**, pp. 1031–1035, (1979).

A two-dimensional curved surface like the surface of the Earth, is easy to conceive as embedded in a three-dimensional world. A curved three-dimensional space is similar by extension: while the parallels are the intersection of the sphere with horizontal planes (of constant coordinate around the center of the Earth), one can "imagine" constructing a sphere in a hypothetical four-dimensional space and intersect it by "planes" of constant coordinate around one axis. The result: concentric spheres that increase and then decrease in diameter. But what plays the role of the coordinate around the axis? The interesting point that Beatrice explains to Dante is that the spheres have a ranking, a "greatness" that does not correspond to their size but that is indicated by their speed. While the diameters increase and then decrease, the spheres' speed of rotation constantly increases as one crosses the Primum Mobile. The topology of Dante's *Divine Comedy* is therefore of a curved space, an idea whose credentials of admission to the world of science had to wait for centuries.

The second Dantesque anticipation comes from *Inferno's* Canto 17, where Dante descends to the seventh circle flying over Geryon, one of Comedy's most complex creatures (Ricci 717). From a mythological viewpoint Dante is not the first to fly and he mentions that Phaeton and Icarus had done it before him. But he is the first to describe the sensation of flying, the crucial point being that, save for the effect of the wind, it is the same as being at rest "As he wheeled round descending; but that I guessed/Only by feeling the wind against my face" (*Inferno,* Canto XVII: 116–117). From a Physics point of view, this is nothing but Galilean invariance, the fact that rest and motion are equivalent for two inertial frames, for systems moving one with respect to the other at constant speed. As a poet, he was far ahead of his time with regard to Medieval views of the laws of nature.

Great poems are profound gazes on reality and great scientific advances redefine the limits of imagination, insinuating a blurry territory of intersection, a shared habitat for science and poetry. Someone against such coexistence is, curiously,

Samuel Taylor Coleridge, who proposes in his *Biographia Literaria* (1817, ch. XIV), that poetry is "opposed to science," since the purpose of science is "to acquire the truth" while that of poetry is to "communicate immediate pleasure." I say "curiously" because Coleridge himself speaks about the poetic faith as the "suspension of disbelief," and precisely from that proverbial suspension in which fiction is accepted as reality, these conceptual structures of modern physics germinated: the Florentine curvatures of space-time, the relativity of time, and wormholes. Richard Feynman, a physicist as eccentric as he is a deep thinker, adheres to the opposite view. To him, science teaches us that the imagination of Nature overcomes that of man and in his essay *The Value of Science,* complains that poets do not try to portray the present view of the Universe, and calls them to sing the value of science.

Why is poetry capable of anticipating science and why are aesthetic criteria, like symmetry and simplicity, qualities of correct theories? That is a great mystery. The resolution of the question may be found, once again, 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.'

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