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# "Energy," the Rise of the Monistic Worldview and the Demise of Perceived Balances

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**Jean Robert**

## A Season Among XIXth Century Physicists

I spent part of the winter of 1981-82 on a cold veranda of the library of the Marburg Physics Institute reading books that were no longer part of the curriculum of modern Physics. There, I delved into the intricacies of the surge of the energy concept, or better of its direct ancestor, *Kraft*, force, and the principle of its conservation. The turning point was a paper of 1842 on the base of which Julius Robert Mayer, a young medical doctor, claimed his priority right on the "discovery" of the principle of the conservation of "force." I write this essay as an exercise in a style of history consisting in interpreting an epoch according to its own concepts. It means that I'll methodologically refrain from reading the modern energy concept in Mayer's formulation:

> Two departments of causes can be found in Nature, and it is a fact of experience, that there are no bridges (*Übergänge*) between them. The first department is constituted by the causes that share the characteristics of "*Ponderabilität*" (the fact of having a "weight," or as a professional physicist would say, a mass) and impenetrability; to the other belong the causes who lack these characteristics […] and that are thus named "*Imponderabilien*" (mass-less entities, that is forces). Forces are thus indestructible and imponderable objects subjects to variations[1] (Trad. J.R.).

[1] "Bemerkungen über die Kräfte der unbelebten Natur," (On the forces of inanimate nature), *Liebig's Annalen der Chemie und Pharmacie*, vol.4, 1842, p.24.

Such dual thinking can be traced back from Antiquity to the eve of modern times. It was part of the "background philosophy" of classical physics until its ideological demise around 1890. My contention is that this background philosophy trained scientists to constant intellectual and moral negotiations between poles of reality that have become incompatible: philosophy and science, human decency and scientific reputation, solidarity and power, tradition and modernity. With the present-day imperative to pu(bli)sh or perish, such balances have been broken by the predominance of one pole over the other: philosophy is tolerated as a servant of science, and moral inhibitions are disregarded for the sake of a career in the sciences. Mayer's claim to the "priority" of the discovery of the principle of conservation of "force"—in reality a *simultaneous discovery*[2]–is a *calculation*, and not an *experiment* performed in 1842. It was more exactly an *experiment in thought* that, according to the constants relating a volume of gas to its temperature and pressure allowed Mayer to calculate the *mechanical equivalent of heat*.

Mayer wanted to align physics with chemistry, paying special attention to the cycles, metamorphoses and mutual conversions of immaterial entities that he called *Kräfte*, "forces," and which later physicists all too easily read as *energy*. For him, a single fundamental principle ruled chemistry and physics: "The quantity of their entities is invariable, only their quality is variable."[3] Unfortunately for Mayer, *his* discovery was first attributed to an alleged competitor, in fact a simultaneous discoverer, James Prescott Joule, who in an *experiment* realized one year after Mayer's *calculation*, obtained a much more accurate value.

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[2] Thomas Kuhn, "Energy Conservation as an Example of Simultaneous Discovery," M. Clagett, ed., *Critical Problems in the History of Science*, Madison: University of Wisconsin Press, 1955, pp. 321-356. Stresses the importance of three general ideas that were so to speak "in the air" : 1. the recognition of circulation and conversion processes; 2. a new interest for machines illustrated by the railroad mania of the 1840's; 3. natural philosophy in the sense of the German idealism.
See also: Jacques Merleau-Ponty, "La découverte des principes de l'énergie: L'itinéraire de Joule, » *Revue d'Histoire des sciences* 32, 1979. Yehuda Elkana, *The Discovery of the Conservation of Energy*, Cambridge: Harvard University Press, 1974. Erwin N. Hiebert, *Historical Roots of the Principle of Conservation of Energy*, Madison: University of Wisconsin, 1962.
[3] P.M. Heimann, "Mayer's 'Concept of Forces': The Axis of a New Science of Physics," *Historical Studies in the Physical Sciences*, 7th annual vol., 1976, p. 284.

**Force: Free Gift of Nature or "Nature's Currency"?**

After Max Planck's definitive mathematical clarification in 1884, a *force* was to refer to what causes a mass to move or modify its motion, while *energy* was expressed mathematically as the path-integral of a force or, in technically controlled motions with constant speed and straight trajectory, the product of a force moving a mass against gravity and/or friction by the distance covered by it, whose unit for the engineer is the *kilogram-meter*. Mayer took that unit—probably from French railway engineers—and magnified it into the paradigm of what remains constant *and can be quantified*[4] in the conversion of Nature's *forces*. He had calculated the conversion rate of heat into mechanical "force," and suspected that similar conversion rates or "relative values" would be discovered to exist between all the forces of Nature.

Under the term "force," were still looming evocations of "the natural forces" such as the rain, the nourishing soil or the wind inflating the ships' veils. By proposing the kilogram-meter as the expression of nature's free gifts, Mayer submitted them to the law of scarcity, and paved the way to the transmogrification of natural conversions into production processes ruled by money. Unwillingly, he opened the door to "energy accounting," a reinterpretation of economics along thermodynamic lines. Yet, in his natural philosopher's decency, he wrote:

> Let's state it from the start: the rule of the relative values ["conversion rates"] of the different forms of forces is only valid for our earthly economic relations, any application of it to the macrocosm's economy is inadmissible[5] (Trad. J.R.).

[4] Mayer "quantifies" with moderation, guided by a kind of classical "everything in its place" perception that modern physicists have lost: "In physics, all is Number, in physiology, little is quantifiable, and in metaphysics nothing […] Time is only productive within our time-horizon. God spoke: let become and it became! We do not entirely support our life-world: it grows and becomes more beautiful," in "Consequenzen und Inconsequenzen der Wärmemechanik," *Naturwissenschaftliche Vorträge von J.R. Mayer*, Stuttgart: Cotta, 1871, pp. 3-16. In this conference on the "consequences and unconsequences of the 'mechanics of heat' (thermodynamics)" to the General Assembly of Natural Researchers in Innsbruck, September 18, 1869 [where Mayer spoke just after Helmholtz], he added: "A correct philosophy cannot be anything less than a propaedeutic of the Christian religion" (p. 16). As we will see, Mayer would sometimes transgress his ingrained sense of the right proportion for his scientific reputation's sake.

[5] J.R. Mayer, "*Consequenzen und Inconsequenzen der Wärmemechanik,*" op., it., p. 7.

**Energy and Force: Free Creations of the Human Imagination or "Ultimate Realities"?**

The extraordinary gifted young Heinrich Hertz (1857-1894) first thought that he would dedicate his life to the humanities. He was proficient in Latin and Greek and never traveled without a copy of Homer in his pocket. He exercised himself as a sculptor and, in at least in one occasion, as an architect. It was Hermann von Helmholtz who lured him into physics by proposing a high-level problem to the auditors of a popular lecture on physics that he delivered at the Berlin University. Hertz, then untrained in the matter, solved the problem by sheer logic and intuition, and that sealed his fate: Helmholtz would not let him go before he had signed his inscription at the Physics department and become his student.

Hertz, the humanist and lover of harmony, simplicity and beauty complained about "the unnatural character of the mingling of the concepts of mechanics with extra-sensorial abstractions." The founder of electrodymamics and discoverer of the "Hertzian waves" had the epistemological aim of cleansing mechanics from "extra-sensorial abstractions" such as force and energy. According to him, these concepts ought to be renounced "as independent fundamental concepts"[6] since only with their complete elimination could mechanics be reestablished as the *science of experience*.

The modern certainty that energy is the ultimate "stuff" of everything does not predispose present-day philosophers to appreciate the depth of Hertz's epistemological reflection. Perhaps their prejudice could be eased if they knew of the lasting influence that Hertz had on one of last century's major philosophers, Ludwig Wittgenstein:

> Both [Wittgenstein's] old and new philosophy shared an inspiration he had come across as a teen-ager in *The Principles of Mechanics* by Heinrich Hertz, a German physicist. Hertz had suggested a novel way to deal with the puzzling concept of force in Newtonian physics: the best approach was not to define it but to restate Newton's theory in a way that eliminates any reference to force. Once this was done, according to Hertz, 'the

[6] "*Die Prinzipien der Mechanik...,*" op. cit., p. 29.

question as to the nature of force will not have been answered; but our minds, no longer vexed, will cease to ask illegitimate questions.'
Ludwig's big idea was to apply this method to philosophical problems.[7]

Hertz's attempt "failed" in the sense that it was not the path followed by mainstream physics. Einstein turned the "vexing" character of force around—being "action at a distance" or "not being located at any point in space"—by reducing it to a local geometrical property of a four-dimensional manifold, but that solution would not have satisfied Hertz, who wanted a reassessment of the relation between physics and sensorial experience. In Hertz' sophisticated spirit, the project of reestablishing a common-sense view of physical *phenomena* free of *a priori noumena* must have echoed the scholastic aphorism *nihil potest esse in intellectu si non fuerit prius in sensu* (nothing can be in the intellect if it was not first in the senses), whose various forms were traced back to Aristotle by the Schoolmen and ulterior philosophers.[8] For a thinker of Hertz's intellectual stature, "energy" pretends to be in *intellectu* without ever being *in sensu*, since there is no direct perception of it, but only of hot or luminous objects, of the speed of the railroad or of electric shocks and sparks in the lab. At the end of the XIXth century, energy was still mainly a principle of equivalence that should not lure a skeptical mind to construe all phenomena as manifestations of an underlying, mysterious, unique reality that nobody, *no body* will ever perceive with her, his or its senses.

Half a generation younger than Hertz, Einstein endorsed the energy concept, but without the naiveté of most of his colleagues. By "geometrizing" it, he recognized that it is an entity that is in the intellect before [and without] being in the senses and insisted that it is part of these "free

[7] Anthony Gottlieb, "A Nervous Splendor: The Wittgenstein Family Had a Genius for Misery," *The New Yorker*, April 6, 2009, pp. 70-74.
[8] One of its last expressions is to be found in F. Jacquier's *Instititiones Philosophicae*, Rome 1833: "*Nihil esse in intellectu quod non prius fuerit in sensu*."

products of human imagination" that determine, not *what* we see, but the *way* we [physicists] see.[9]

## The "Science of Experience" Loses Both Its Propaedeutic Language and Its Relation to Perception

In the last decades of the XIXth century, physics was disembodying itself from common language into one of its own. After the demise of the old linguistic continuity between science and everyday life, the path was open to *monism*. Scientific monism is the belief that a single principle ought to rule everything without opposition through the utter formalization and mathematization of all forms of once empirical knowledge.[10] It is the dictatorship of one unique form of thought, one unique perception of reality, one unique language, one unique space. It expresses the utopia of a world without conflicts, resistances, distances and dissidences; a world where negotiations, checks and balances, arbitrations between contradictory imperatives, old forms of "coming to terms," and even politics would have become obsolete.[11]

## Energetism and the Panderage of Tax-payers By a New Synthetic Language

For Wilhelm Ostwald, a longtime redactor of *Der Monist*, a journal he helped found in 1906, *energy* was not an "invention," an "extra-sensorial hypotheses" imposed on experience (Hertz) nor "a free product of human imagination" (Einstein). Energy was now the ultimate and unique "stuff" of which everything was made. In *Der Monist*, he fought the "fallacious" diversity

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[9] Albert Einstein, "Foreword," Max Jammer, *Concepts of Space. The History of the Theories of Space in Physics*, New York: Dover Publications, 1993 [1954]. For Einstein, the mathematical concept of space was one of these "free products of the imagination" that determine how we see (p. xv). Energy was another.

[10] Michel Foucault, *Les mots et les choses. Une archéologie des sciences humaines*, Paris: Gallimard, 1966, particularly chapter 7. English version, *The Order of Things. An Archaeology of Human Sciences*, New York,Vintage Books/Pantheon, 1970. The formalization and mathematization of knowledge weakened traditional forms of empirical, not formally scientific knowledge.

[11] See Jean Robert, "*Der Verlust der Erläuterungssprache in der Physic von 1840 bis 1900*," Stephan H. Pfürtner, ed., *Wider den Turmbau zu Babel. Disput mit Ivan Illich* (Against the (re)-construction of the Babel Tower. Debate with Ivan.Illich), Reinbek bei Hamburg: Rowohlt, 1985, pp. 116-130, 152, 153.

of the phenomena and called for a recognition of a sole imperative, the "energy imperative" to supersede the diversity of moral imperatives. Hence *monism* was also called *energetism*. According to Ostwald, "[e]nergy comprises the complete reality";[12] it rejects all forms of dualism and no other fundamental concept is needed to describe it. Monism had also linguistic effects. The demise of the physicists' ability and willingness to explain their ideas, discoveries and theories in a language accessible to a general public had made of physics an esoteric parlance only understandable to close colleagues. Ludwik Fleck has studied how esoteric languages also produce esoteric facts that utterly alter the life-world of modern man.[13] Lest physicists become philosophical anchorites, only equipped, like young Einstein, with a pencil and a pad, they must beg tax-payers for funding, and for this, a new synthetic language had to be invented. Modern science is a conglomerate of separated and often conflicting *thought collectives*, each attempting to make its *thought style* prevail. A scientist has hardly any degree of freedom relatively to his collective: belong or perish.

According to Fleck, the first signal of a new *scientific fact* is a line of resistance within a given *thought style*. As long as it has not reached the "public" along a chain of ever less specialized transmitters, the signal is not a "fact." A scientific fact has always a sociological weight acquired through what Fleck calls the *migration of ideas*. This migration from specialized to less specialized circles can be called popular science or *pop science*. Unlike the old propaedeutic language of science, pop science—which for Fleck is sociologically as much a part of modern science as the productions of its most inner circles—does not proceed by careful expositions and explanations. Rather, through apodictic statements, bright colored descriptions, and premature affirmations, pop science makes unquestionable *facts* out of *ideas*. The broad

[12] Wilhelm Ostwald, *Vorlesungen über Naturphilosophie*, (Lessons on Natural Philosophy), Leipzig, 1901, see particularly pp. 146, 146, 377.
[13] Ludwik Fleck, *The Genesis and Development of a Scientific Fact*, Chicago: Chicago University Press, 1979 [1935].

public, most exoteric of the circles, then functions as a mirror that sends a received "fact" back to its circle of origin, where the surprised and flattered scientists tend to accept this sociological transmogrification of their original idea. It is how energy, originally a principle of equivalence between Nature's forces, an extra-sensorial hypothesis, and a free construction of the imagination became, for the broad public and the scientists alike, an unquestionable fact. The difference here between, on the one hand, Hertz and Einstein and on the other, Ostwald, is that while the formers insisted on *how* they saw, the latter dumped one brutal *fact* upon the half-consentient public: *there is nothing but energy*, a universal recipe for intellectual freewheeling. *Monism* helped as well channel further funds toward society's continuous need of ever more *Research and Development* (R&D) on energy "needs," energy-related concepts, processes, resources, systems, economies or wars.

**Hugh's *Mechanica* and The Blind "Fleck" of Hertz' Mechanics**

In 1983, in a public talk at the *Colegio de México*, Ivan Illich analyzed the linguistic differences between a scientific symbol, *E*, and *energy*, its pop science twin. [14] *E* has a pure denotation, generally compacted into a mathematical formula, while *energy* has only connotations of which physicists tend to prudishly distance themselves in private conversations, while anonymously endorsing them, pertinently knowing that these connotations are part of the propaganda by which their profession panders tax-payers for more R&D funds.

Building on that idea, Professor Uwe Poerksen, a German linguist, compared a denotation with the point of impact of a stone thrown into a pond, and connotations with the resulting concentric waves:

[14] Ivan Illich, "The Social Construction of Energy," opening talk to a seminar on *The Basic Option within any Future Low-Energy Society*, Colegio de México, México, July 1983.

.. …Energy… Energy…Energy … Energy E Energy… Energy… Energy …Energy……

Poerksen discovered with astonishment that *energy* was part of a *new class of words*, rich in connotations and as deprived of precise denotation. In his path-breaking book, *Plastic Words. The Tyranny of a Modular Language,* he identifies how modern society builds its certainties and social theorems through semantic "Lego"-blocks such as energy, information, communication, resource, factor, system.[15]

While I was sitting on the cold veranda in the company of the old physicists exiled from their science's new curriculum, Ivan Illich, who had invited me to Marburg to talk about the history of the energy concept at his table of convivial friends, was teaching medieval history at the university. He was attempting to make his students feel how ill-equipped they were, conceptually and bodily, to understand a twelfth-century pilgrim, or even what the philosopher-monk Hugh of Saint-Victor meant, when he said that reading was a *peregrinatio in stabilitate*, a pilgrimage in stability.[16] In 1980, the author of *Tools for Conviviality*[17] and *Energy and Equity*[18] had written a short essay to honor Hugh as a colleague he had discovered in the XIIth century.[19] In this text, Illich commented the *Didascalicon* written by Hugh around 1127-1128, focusing his attention on Hugh's concept of what he called *mechanica*. In his uniquely radical way, the philosopher of the mechanical arts was interested in the relation between science and society.

> Hugh defined mechanical science as the part of philosophy which studies remedies for bodily weakness, when such weakness derives from humanly-caused disruptions of the environment—science, then, is a corrective for an ecological disorder. Asked to clarify

[15] Uwe Poerksen, *Plastic Words. The Tyranny of a Modular Language*, University Park: Pennsylvania University Press, 1995 [Original: *Plastikwörter.Die Sprache einer internationalen Diktatur*, 1988].
[16] Years later, Illich dedicated a book to Hugh's Art of Reading, *In the Vineyard of the Text: A Commentary To Hugh's "Didascalicon."* Chicago: University of Chicago Press, 1993.
[17] Berkeley: Heyday Books, 1973.
[18] London: Calder & Boyars, 1973.
[19] *Hugh? Or Science by People?*, Cuernavaca: *Tecno-política*, ed. Valentina Borremans, Apdo 479, 62.001, Cuernavaca, Mexico, later reproduced in *Shadow Work*, London, Boston: Marion Boyars, 1981.

> the notion of a new conception of science which underlies the various movements of science by people, I know of no better approach than a confrontation with Hugh of St Victor's thought.[20]

Hugh's *mechanica* was infused with a deep apprehension of sensorial perceptions and their aesthetics and of the fitness of mechanical artifacts to the body. Paraphrasing Joseph Kockelmans,[21] a physicist and a philosopher, I dare say that "modern mechanics is an attempt to say anything meaningful about the physical world without any consideration of the body." What would be a mechanical art that would *start* with the body and the relations of mechanical artifacts to the hand, and relate their power to their scale and their radius of action to their *distality*? How much "abstraction" would it need? It is a contest open to talents.

[20]Op. cit., p. 4

[21]The sentence, with "philosophy" instead of "mechanics" was pronounced by the dean of the Philosophy Department, Professor Joseph Kockelmans, at the occasion of a meeting with Ivan Illich and Barbara Duden at Penn State University.