



ANGELO PAGANO

knowing and *understanding*
science, its history and its foundations

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Inspiration from crucial meets

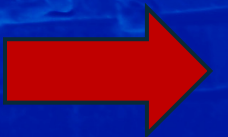
In those unforgettable meetings, we explored the history of physics from its Pythagorean origins to the present day; and not just physics.



Salvatore Notarrigo, Full professor of *Fisica Superiore* at the University of Catania

I didn't have Salvatore Notarrigo as a teacher... but I wanted to get to know Notarrigo as a professor. So I enrolled in graduate school and specifically chose to include the subject "Physics Teaching" in the curriculum, which I began to follow regularly with curious devotion. [...] He exposed topics I'd never encountered before in courses, and with his epistemological critique of the foundations of physics, he shattered my certainty in the two pillars of modern physics: relativity and quantum mechanics. This made me rediscover the validity of Galileo-Newton's classical physics, which the teaching paradigm treated as approximate theory.

but something deeper was being born...



a long theoretical-epistemological elaboration, [...] the fruit of interminable conversations, of his lectures [...] and of a broad research program, which involved various fields of knowledge. We formed the shared conviction that a pernicious paradigm had imposed itself in the sciences between the late nineteenth and early twentieth centuries. This had its roots in the ancient thought of Plato and Aristotle; when the unity of science was shattered, the separation between logic, physics, mathematics, and philosophy had taken hold, and with it the empiricist paradigm. The separation between magnitudes and numbers, that is, between mathematics and physics, initiated by Plato, was revived at the end of the nineteenth century by Dedekind. Aristotle's grammatical logic was reborn under the false guise of mathematical logic. All the sciences were affected by the empiricist paradigm [...].

It was then a matter of recovering the ancient ideal of the Italian scientist-philosophers, of a unitary and indivisible science, where, since there were no separations between knowledge, physics, mathematics, logic, and philosophy went hand in hand. We began a long journey of reappropriation and reworking of that ancient Italian thought, which went by the names of Pythagoras, Parmenides, Democritus, Archimedes, and so on, passing through its rediscovery by Galileo and Newton, up to Boltzmann and Peano.

All of Angelo Pagano's works reflect exactly this approach, and his first articles outlined his historical-epistemological research program that lasted more than thirty years, producing more than thirty papers:

- critique of the theory of relativity
- critique of classical physics (foundations; mass; interaction)
- pre-Galilean physics (Democritus, Archimedes, Leonardo)
- teaching of classical mechanics, relativity, probability
- sustainable development; global warming

1989	A. Pagano	On a forgotten paper on physics by Boggio and Burali-Forti
1991	A. Pagano	Reflections on physics teaching
1992	G. Boscarino, S. Notarrigo, A. Pagano	Geometry and Physics [Peano and the foundations of Mathematics, Modena, 1991]
1993	P. Di Mauro, S. Notarrigo, A. Pagano	The power of paradigms: The cosmic aether and Augusto Righi's critique of the Michelson-Morley experiment
1993	A. Pagano	On the Newtonian concept of mass
1994	A. Pagano	Sustainable development and physical economy

On the foundations of the theory of relativity

The most substantial part of Angelo Pagano's work as a historian/epistemologist, which occupied him for three decades, concerned the criticism of the theory of relativity...

1989	A. Pagano	On a forgotten paper on physics by Boggio and Burali-Forti	Quaderni di Mondotre
1989	A. Pagano	Physics and Metaphysics in Einstein's theory	Quaderni di Mondotre
2000	A. Pagano	Mythological aspects in the theory of relativity	Mondotre
2003	M. Consoli, A. Pagano, L. Pappalardo	Vacuum condensates and 'ether-drift' experiments	Physics Letters A
2015	P. Di Mauro, A. Pagano	A note on the historical criticism of Lorentz transformations in special relativity	SISFA Proceedings
2016	P. Di Mauro, A. Pagano	Criticism of the "vectoralists" Burali-Forti and Boggio to General Relativity	SISFA Proceedings
2019	A. Pagano, E.V. Pagano	A note on Lorentz transformations and simultaneity in classical physics and special relativity	European Physical Journal H

1993	P. Di Mauro, S. Notarrigo, A. Pagano	The power of paradigms: The cosmic aether and Augusto Righi's critique of the Michelson-Morley experiment	Quaderni di Mondotre
1995	P. Di Mauro, S. Notarrigo, A. Pagano	A re-examination of Augusto Righi's theory on the apparatus of the Michelson-Morley experiment	SISFA Proceedings
1997	"	"	Quaderni di Storia della Fisica
2020	A. Pagano, E.V. Pagano	Augusto Righi's research about Michelson's interferometer	SISFA Proceedings

also including the specific study on Augusto Righi's criticism of the Michelson-Morley exp.

A general consideration as a starting point:

*In the teaching of relativity [...] mathematical formulas are given that are presented as physical laws without adequately clarifying the distinction between **theory** and **model**, between **general ideas** and their translation into **formulas**. The latter, being only a representation (necessarily transitory and therefore imperfect) of those general ideas, are always susceptible to modification or subsequent refinement. [...] The question is: what general ideas does Einstein's relativity advance? [...] I would add that in Einstein's work and in the subsequent work of his students [...] there is a lack of reference to the **general ideas that must be referred to for even a heuristic understanding of the theory**. Relativistic formulas do not at all represent mathematical deductions (perfect or imperfect) of mathematical translations (models) of general ideas.*

More specifically on Lorentz transformations:

Lorentz transformations are not a unique feature of the theory of relativity. They find broad applications in the modern theory of acoustic waves or, more generally, in Newtonian models of mechanical wave propagation. Both the acoustic and electromagnetic Doppler effects are properly described by the same transformation, which [...] should be called Voigt's, after the scientist who first established it in 1887. [...]

Somigliana (1922), starting from these considerations, denies that the properties of the Lorentz transformation can be used to deduce an interpretation in favor of Einstein's relativity. We believe that the conclusion reached by Somigliana has significant logical-experimental validity, which has not been given the due recognition. [...] The most important aspect between the two different interpretations of LT, namely the *Newtonian interpretation* and the *Einsteinian interpretation*, is that the former leads to considering the correspondence established by LT as a correspondence between *different events*, while the Einsteinian interpretation recommends a correspondence between coordinates relative to the *same event*, thereby nullifying the notion of simultaneity of events as assumed in classical physics. This difference in interpretation makes the classical viewpoint irreconcilable with the relativistic one, even in the extreme limit of values of particle velocities negligible in relation to the speed of light.

Einstein's early criticism of the notion of "absolute simultaneity" appears defective. Einstein pointed out the contradiction between the postulate of the speed of light invariance and the use of GT in connecting like-light events. However, he [...] neglected the Doppler Shift Effect. [...] It is argued that, with respect to Einstein's early criticism, the concept of absolute simultaneity still remains an open problem in physics.

On the foundations of classical mechanics

Historical-epistemological studies on several concepts and notions in classical physics:

There is one point on which everyone agrees: there is the world of the senses and there is the world of reason. But the agreement immediately ceases when it comes to establishing to what extent scientific discourse should appeal to one or the other of the two worlds. [...] The answers to this problem have always been the most varied since the most ancient times [...]. Compromise positions have always appeared flawed and inconsistent, especially in physics and other sciences that must refer to empirical facts.

1992	G. Boscarino, S. Notarrigo, A. Pagano	Geometry and Physics [Peano and the foundations of Mathematics, Modena, 1991]	Quaderni di Mondotre
2021	A. Pagano, E.V. Pagano	A transition in the notion of interaction in Classical Mechanics	SISFA Proceedings
1993	A. Pagano	On the Newtonian concept of mass	Quaderni di Mondotre
2019	A. Pagano, E.V. Pagano	A logical analysis of the Newtonian concept of mass and modern applications	SISFA Proceedings
2021	A. Pagano, E.V. Pagano	Mach's criticism against the Newtonian concept of mass revisited	European Journal of Physics

A paradigmatic change in the foundations of classical mechanics:

In Newton's early mechanics, the two notions of impenetrable body or solid and interaction by shock or contact had the role of elementary concepts. The modern notion interaction at a distance had the value of phenomenological model, useful provisory to describe the measurable effects of accelerations of separated (in space) bodies. In the post-Newtonian mechanics, the notion of interaction at a distance assumes the value of fundamental assumption. As a consequence, a transition in the notion of interaction among bodies from early Newtonian to Post-Newtonian theory of (non-relativistic) mechanics is evidenced.

The success of the notion of interaction at a distance in explaining the phenomena of celestial mechanics changed the opinion of undecided savants and the new concept progressively became a common concept in mechanics. [...] Point-like particles (no size) and interaction at a distance replaced the notions of impenetrable solid and interaction by shock in the foundations of mechanics. The historical result was that the elements of the foundations of the mechanical theory, as it is understood today, are substantially different from the ones of the pioneers, like Galileo, Newton, d'Alembert and others.

A fundamental concept revisited, according to original Newton's definition:

The mass is the quantity of matter of an object proportional to the volume of the body. The constant of proportionality is an intrinsic property of the material from which the object is constructed, i.e. its density. The density of the object depends on the density of the solid entities making up the object and their configuration. [...] The elemental constituents of an abstract matter are indestructible bodies, as postulated by early atomists (Democritus and Leucippus). Remarkably, this elemental indestructibility has a surprising analogy with the modern concept of conservation of the baryon number.

In textbooks devoted to the secondary and university educational system we note an ambiguous position. On one side, the notion quantity of matter is avoided in the presentations of Newton's law of motion: inertial mass is assumed, any inertial mass reference unit - useful for metrology - is not defined. [...] The Newtonian concept of mass does not represent any logical tautology and it allows us to fully justify the notion of density of a sensible body, in agreement with the modern metrology.

Rediscovering the ancient philosophers-scientists

Building a bridge between ancient and modern science: from Democritus, Archimedes, etc. to Galilei, Newton, etc.

It is fair to recognize that the general ideas of Galileo-Newtonian (classical) mechanics are a (conscious, according to what Galileo himself testifies) rediscovery of Democritean physics.

2007	A. Pagano	Physical theory and concrete models in Democritus	SISFA Proceedings
2011	A. Pagano	The mechanical model of solid bodies in Democritus' physics	SISFA Proceedings
2022	A. Pagano, E.V. Pagano	Democritus: The mechanical model revisited	Quaderni di Storia della Fisica
2017	A. Pagano, G. Boscarino, O. Caniglia, E.V. Pagano	Elements of geometrical calculation in Archimedes. The laws of statics	SISFA Proceedings
2021	E. Recami, A. Pagano, S. Di Paola	The conservation of linear momentum in Leonardo da Vinci	Quaderni di Storia della Fisica

Recognizing the seeds of modern science in the first scholars:

Interdisciplinary work is strongly recommended both in scientific studies and in those more specifically aimed at teaching and dissemination. Our research follows the method of conceptual investigation [...]. It is conducted through the reading of fragments and testimonies known in the literature and aims to highlight the seeds of mechanics, as the science of motion, and cosmology in the naturalistic model of Democritus, among the first physical models to have come down to us from Greek-Roman antiquity. The study of a past doctrine can serve to illustrate characteristic features of modern science.

Democritus

The concept of collisional interaction between impenetrable solids and the concept of determinism are primarily compared with the mechanical theory of d'Alembert and Laplace. Democritus's cosmological model is also highlighted and included within the framework of an infinite, stationary universe.

Archimedes

The work of Archimedes strongly influenced the development of modern science. In this report, the laws of statics are discussed within the modern “geometrical calculus”, such as the one provided by the mathematician Giuseppe Peano. The translation of Archimedes' work by symbolic logic is made possible by the unambiguous terms used by Archimedes in his postulates and propositions. The formal results are also applicable to the theory of the collisions between two impenetrable bodies, as the one described in d'Alembert's mechanics. This modern axiomatic interpretation is a clear indication of the existence in Archimedes' work of a complete set of logical rules (precursor) whose real interpretation is consistently illustrated by different physical models.

Leonardo

Through the experimental method and mathematical demonstrations, Leonardo showed that he possessed the essential elements of that vast scientific program which would culminate [...] in the theoretical edifice of classical mechanics, understood in a modern sense; and, in particular, he already had a clear understanding of the principle of the conservation of momentum.

Reflections on (physics) teaching

[For those who] would like to reflect a little more on the consequences and usefulness of what is taught in schools or universities, so as not to give young people the impression that science doesn't help us understand the world around us, but only makes miracles seem possible. Some particularly sensitive young people might ask themselves the question: if science doesn't help us understand, what's the point of doing science?!

- energy, mass, light, electromagnetic field, Einstein's theory of relativity
- centrifugal force
- classical probability (Laplace-Peano; Kolmogorov)

1991	A. Pagano	Reflections on physics teaching	Quaderni di Mondotre
2022	A. Pagano, E.V. Pagano	Appearance and reality of centrifugal force: A still current educational question	SISFA Proceedings
2002	A. Pagano	On the concept of classical probability	Giornale di Fisica
2003	A. Pagano	Probabilities: Axiomatics compared	Giornale di Fisica

A definite approach in doing science and teaching science, choosing between two divergent paths...

[One formulation], that of Peano-Laplace, proceeds by successive abstractions from conceivable physical models through an incessant series of applications. Its semantic framework is undoubtedly formal-empirical in nature, in which the intuitive aspect plays an important role. The other, that of Kolmogorov, embodies the ascetic nobility of axiomatics, which, in the obsessive quest to free science from everyday empirical reality, devastates it. The formal empirical reality is replaced by a complex edifice of axiomatic relations whose meaning is not always easy to clarify in reference to concrete physical models. [...] It is hard to believe that a seemingly innocuous concept like probability, which would seem to arise directly from concrete applications, could conceal the eternal opposition between very different ways of conceiving scientific research!

Beyond physics and its history

Insights into economic theories with approaches that are similar to the way problems are treated in physical science

a quantitative growth which, tending to discard the intrinsic "social value" of the goods produced, has clashed with the ecosystem's regeneration capacity and, therefore, with the consequences of the law of entropy.

1994	A. Pagano	Sustainable development and physical economy	Quaderni di Mondotre
1999	A. Pagano	Elements of Economics: A more physical science-like approach according to the ideas of Von Neumann, Sraffa, and Notarrigo	Mondotre
2001	A. Pagano	Sustainable development between myth and reality	Mondotre
2010	A. Pagano	Technological development: Science and the economic system	SISFA Proceedings
2005	A. Nigro, A. Pagano, F. Zuccarello	Global warming: solar variability and energy consumption	Memorie SAIIt

A clear program for a well-defined problem:

*Classical antiquity did not experience a «machinery» that is, a widespread social application of technological inventions, despite science having achieved a highly advanced system of ideas. [...] The cause must be sought in **the functioning of the economic system**; that is, in **the system of wealth redistribution** and in **the policy of productive investment**.*

***Global warming** of Earth's surface during the last two centuries has been analyzed by a simple thermodynamic model including both anthropogenic and solar forcing. The average trend of the temperature anomaly as a function of the time in the period 1860-2000 years, was found similar to the one observed in world **energy consumption rate**.*

Those who control the economy do not always "play" by making the "best possible move"; or in the extreme (but possible) hypothesis that nature might make its "worst move" (natural disasters); or again, in the extreme (but possible) hypothesis that humans might engage in the most unworthy behavior possible (Nazism), and so on, until the most rational use of resources compatible with natural constraints can be achieved.



Thank
you,
Angelo!