

CREIERUL CUANTIC

At the birth of the 20th century, science was generally accepted to be in a satisfactory state of health. Generations of natural philosophers had built a coherent structure which stood on foundations laid 400 years earlier by G. Galilei and I. Newton.

There is a well-defined relationship between cause and effect and the physical laws give no 'freedom of choice'; identical experiments give identical results. This principle was taken as an axiom, self-evident and necessary for the very existence of science.

Within this paradigm Newton's laws explained the motion of the planets and even predicted the existence of an undiscovered planet.

Thermodynamics described processes involving heat energy with great accuracy.

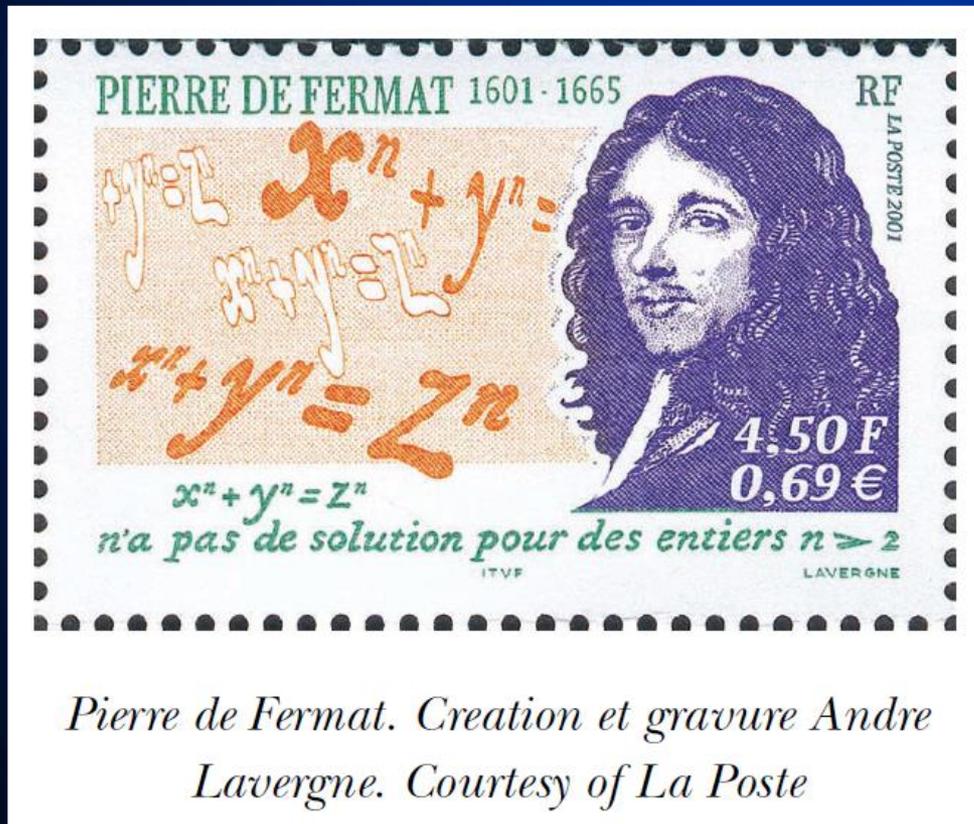
Maxwell's equations led to a complete understanding of how electric and magnetic fields behaved; his ultimate triumph was to show how electromagnetic waves, such as light and radiowaves, were produced.

Nature is thrifty in all its actions

Pierre Louis Maupertuis (1744)

*Montwill Alex, Breslin Ann. The Quantum Adventure.
Imperial College Press. 2012*

"Last Theorem" which states that it is impossible to find integer values of x , y and z which satisfy the 'simple looking' equation $x^n + y^n = z^n$ when n is greater than two.



"I have a truly marvellous demonstration of this proposition which this margin is too narrow to contain".

Montwill Alex, Breslin Ann. The Quantum Adventure. Imperial College Press. 2012

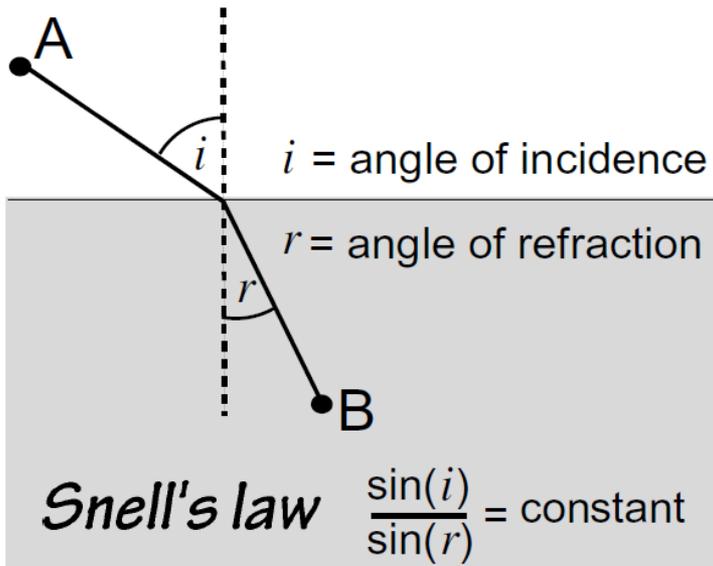
No one else could solve the problem, and a prize of 100,000 marks was lodged at the Academy of Sciences in Göttingen, for anyone who could find a complete proof of Fermat's theorem for all values of n . It was not until 1997 that the English mathematician, Andrew Wiles, published a complete proof; it represented 11 years of work and involved 60 pages of mathematics. !

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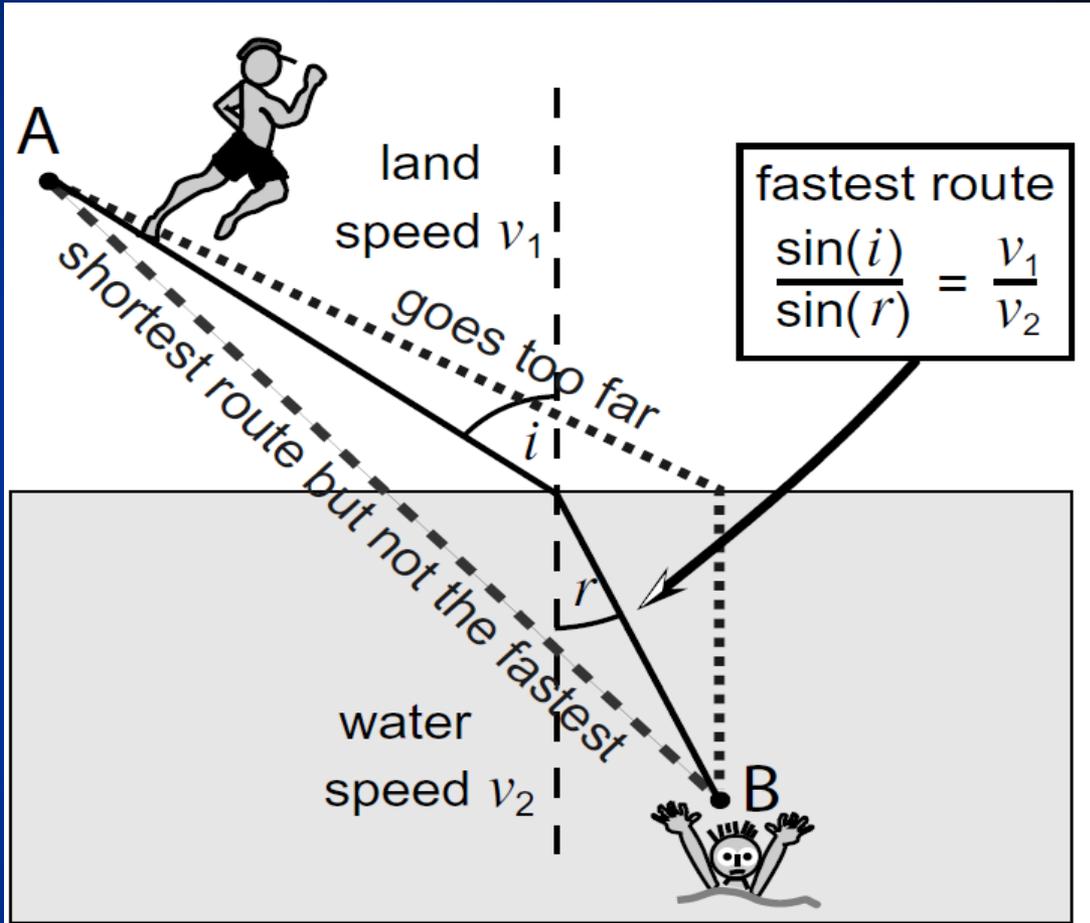
Fermat's principle of least time

Fermat took a global view. What has become known as Fermat's principle of least time states that when light travels from one point to another, it always chooses the route which takes the shortest time. His hypothesis was based on intuition and the belief in the perfection of natural laws. Fermat could not have known the speed of light; in his time there was a general acceptance of Aristotle's dogma that the speed of light is infinite.

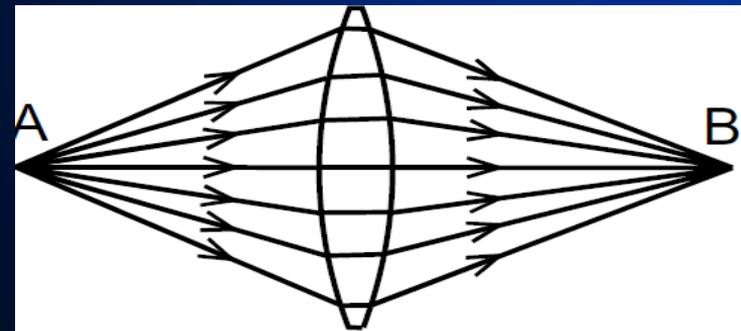
In 1621, Willebrord Snell (1580–1626) made systematic measurements of this change of direction, and found that it depends on the angle at which light strikes the boundary between the materials. He showed that the ratio of the sine of that angle to the sine of the angle at which the light leaves, is constant. This constant is known as the refractive index for light passing between the two materials.



Snell's law



Lifeguard's quickest route



A choice of routes all equally quick

The principle of least action

Leonhard Euler (1707–1783), Joseph Louis Lagrange (1736–1813) and Jean Le Rond D'Alembert (1717–1783) all contributed to the development of a mathematical formalism to express Maupertius' notion of nature's thrift.

They quantified 'economy' in terms of the difference between energy due to motion (kinetic energy) and energy due to position (potential energy). This somewhat mysterious function became known as the *Lagrangian*.

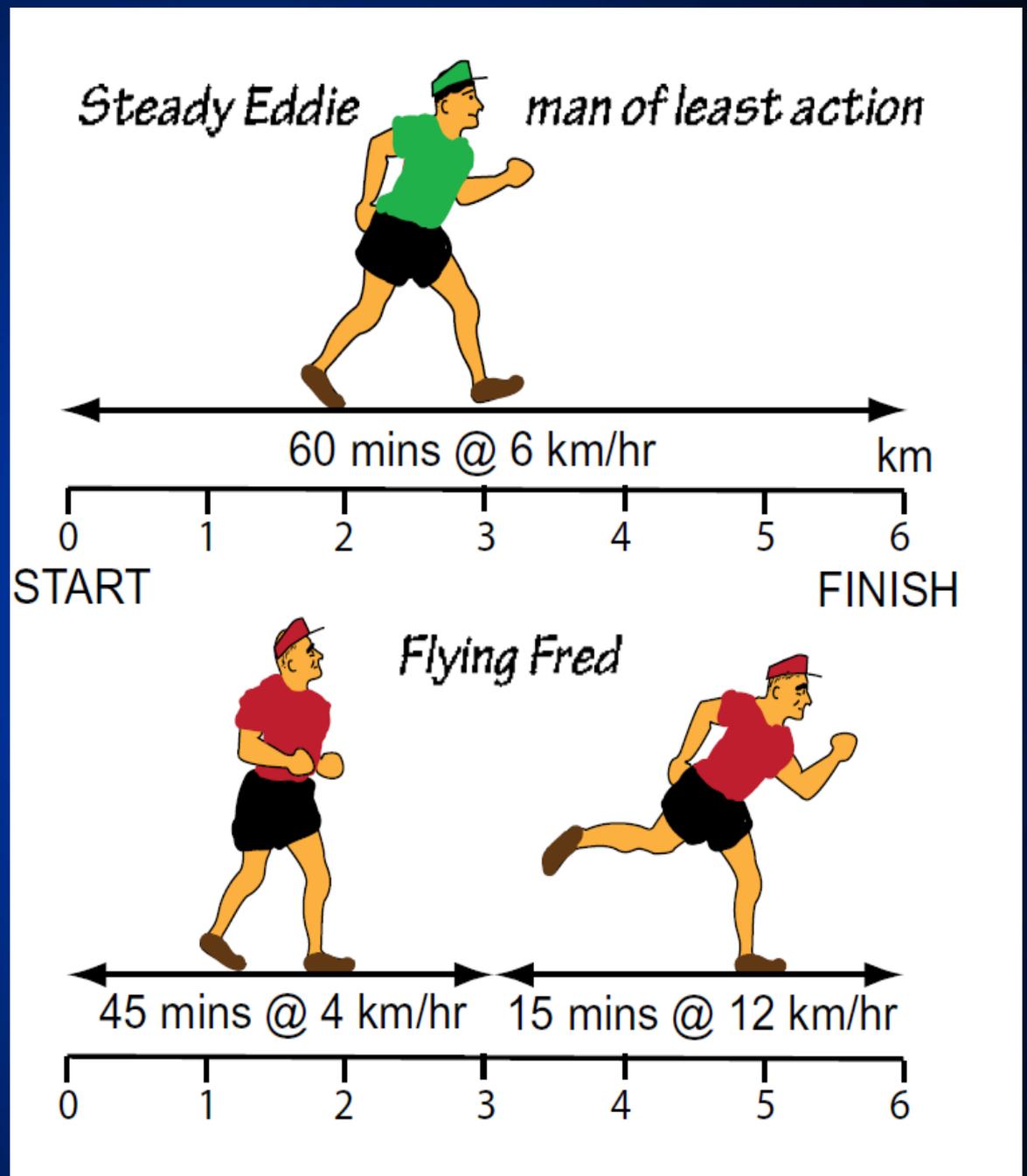
Principle of least action

$$\text{Action } S = \int L dt$$

is a minimum

Lagrangian, $L = (\text{kinetic energy} - \text{potential energy})$

Fermat's law applies specifically to the path taken by light, which raises the fascinating question: 'Can Newton's laws be derived from a similar universal principle which applies to all natural phenomena?'



Planck's Adventure

On 21 October 1874, a 16-year-old student named Max Planck (1858–1947) entered the University of Munich. He chose to study physics, but was warned by his professor, Philipp von Jolly that this branch of Natural Philosophy offered no real prospects. The laws of physics were fully understood. Nothing new remained to be discovered

Planck's Adventure

In trying to understand the basic process of light emission from glowing hot metals, Planck was confronted with the perplexing situation that, according to the 'well-established' theories, the amount of energy emitted from a hot metallic surface should be infinite. Something was very wrong. "A solution had to be found at any price". In "an act of desperation", Planck proposed that energy is emitted, not smoothly, but in indivisible 'bundles' or quanta.

Einstein, Bohr and Born Come on Board

At first, most of Planck's peers did not take him seriously but there were exceptions, notably Albertt Einstein, Niels Bohr and Max Born,who embraced the new idea with enthusiasm.

It soon became clear that Planck's 'act of desperation' did much more than introduce a radical new concept regarding the emission of energy. It had knock-on effects which led to far-reaching departures from well-established scientific principles.

One of these effects was to introduce spontaneous 'quantum jumps' between 'allowed' energies in the atom.

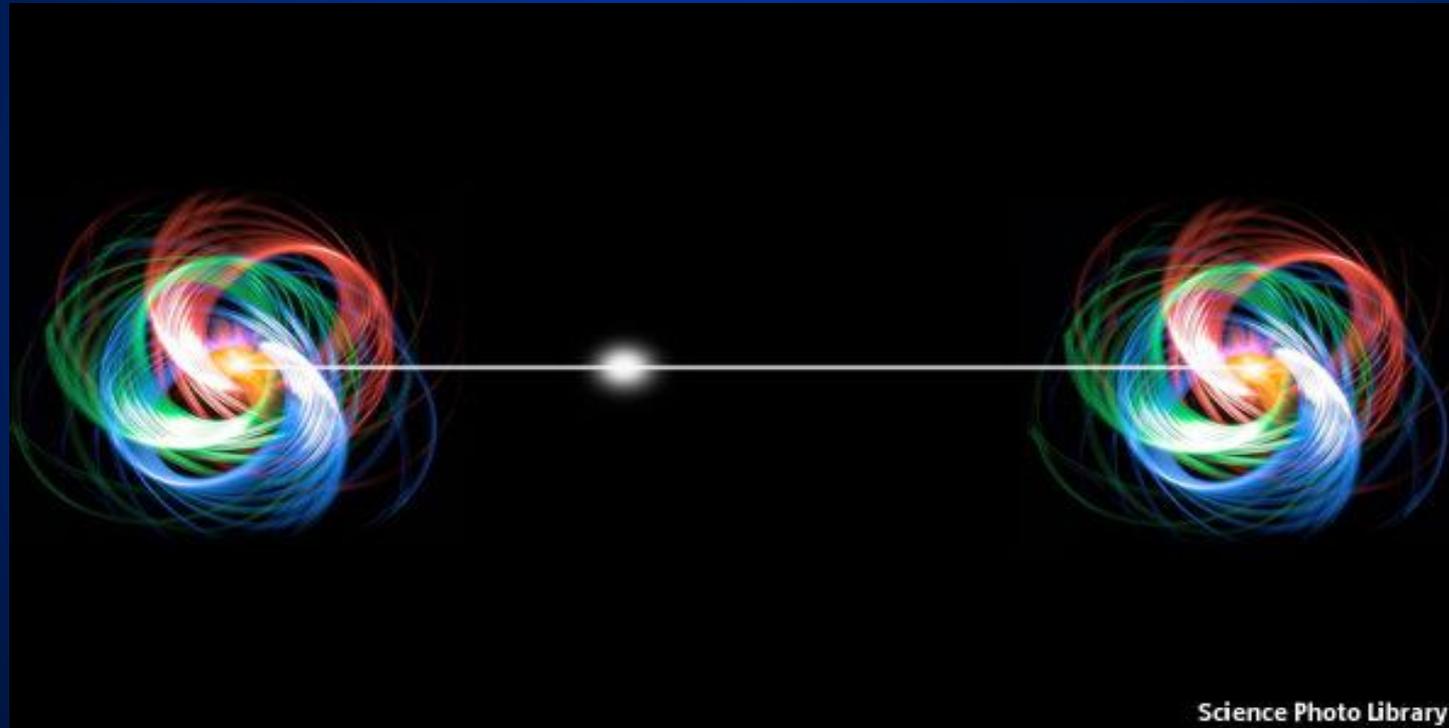
These were assumed to be unpredictable, which meant that atomic phenomena do not follow a predetermined path but are governed by probability, a symbolic 'throw of the dice'.

Albert Einstein could not come to terms with this development. In his view, the scientific method demands that the same initial conditions must always lead to the same sequence of results.

He could not accept that the future of the universe is determined by successive arbitrary events at the atomic level: 'Der Alte würfelt nicht: God (the Old One) does not throw dice'.

Erwin Schrödinger, another central figure in the development of the theory, joined Einstein in the camp of the objectors. To demonstrate the absurdity of what he had helped to create, he expressed his doubts in the paradox of Schrödinger's cat, which is mysteriously both alive and dead.

That same year, Einstein, together with Boris Podolsky and Nathan Rosen came up with an even more subtle paradox, involving "spooky actions at a distance".



What is spooky action at a distance?.

<https://www.economist.com/blogs/economist-explains/2017/03/economist-explains-13>

In quantum technology, quantum-mechanical effects once deemed merely odd are now being put to use. Entanglement can help vastly increase the precision of sensors and navigation, underpin the fundamental unhackability of quantum-enabled networks and empower novel computers to solve some classes of problems that grind current supercomputers to a halt. Einstein called entanglement spooky, and perhaps it is; eight decades on and he would have conceded it is useful, too.

...electromagnetic fields normally serve as conveyors of information from the environment to the organism, within the organism, and among organisms. He postulates that in the course of evolution organisms have come to employ these fields in conjunction with the well-known sensory, nervous, and endocrine systems in effecting coordination and integration.

*Presman A. S. Electromagnetic Fields and Life.
Springer Science+Business Media. 1970*

The postulation that normal informational roles are played by these fields for living systems at three levels is systematically developed as logical, plausible consequences and significances of the reported responsiveness of living systems to diverse experimentally applied fields, and characteristics of these responses

A good case is made for the thesis that the capacities occur in their fullest state of development only in the organism as a whole, and are either not present, or not present in comparable form, at the molecular level

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Most of the external physical factors which have been implicated in the evolution of life are of an electromagnetic nature. It has now been established that throughout the reviewable geological period the biosphere has been a region of electromagnetic fields and radiations of all the frequencies known to us - from slow periodic variations of the earth's magnetic and electric fields to gamma rays.

*Presman A. S. Electromagnetic Fields and Life.
Springer Science+Business Media. 1970*

It appears that in the process of evolution living nature has used EmFs to obtain information about the changes in the environment. The EmF, of course, is the most reliable information-carrier among geophysical factors. By means of EmFs-information can be transmitted (in the appropriate frequency ranges) through any medium inhabited by living organisms and in any meteorological conditions - during the polar day or night, in river and sea water, within the earth's crust and, finally, in the tissues of organisms themselves

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There is not only the already known transmission of information along the nerves by bioelectric pulses with a frequency spectrum extending to thousands of hertz, but also the long-range interactions effected by EmFs of very different frequencies – from infrared to superhigh frequency.

They are manifested in the electromagnetic interrelationships between macromolecules, in the synchronization of the electromagnetic vibrations in assemblies of macromolecules and groups of cells, and so on

In the general case three kinds of activity are probable:

1. The effect of electromagnetic processes taking place in the environment on the functioning of living organisms.

2. The role of electromagnetic processes taking place within organisms in the vital activity of organisms.

3. Electromagnetic interconnections between organisms.

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Springer Science+Business Media. 1970*

I had a beautiful experience which set me on a road that has led to the writing of this book. I was sitting by the ocean one late summer afternoon, watching the waves rolling in and feeling the rhythm of my breathing, when I suddenly became aware of my whole environment as being engaged in a gigantic cosmic dance. Being a physicist, I knew that the sand, rocks, water and air around me were made of vibrating molecules and atoms, and that these consisted of particles which interacted with one another by creating and destroying other particles.

Fr. Capra. The Tao of Physics. Shambhala Publications, Inc . 1975