PEDAGOGICAL EXERCISE

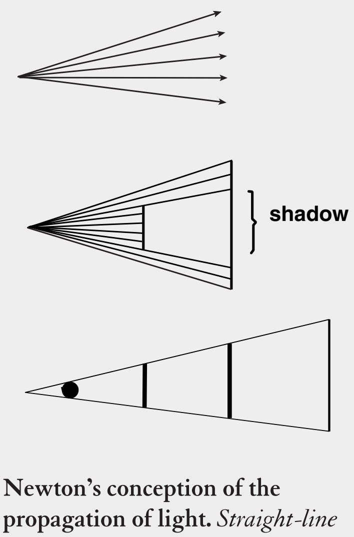
'Poisson's Spot': The Transfinite Principle of Light

We are in Paris, at the highpoint of the oligarchical restoration in Europe, the period leading up to and following the infamous, mass-syphilitic Congress of Vienna. Under the control of Laplace, the educational curriculum of the famous *Ecole Polytechnique* is being turned upside-down, virtually eliminating the geometrical-experimental method cultivated by Gaspard Monge and Lazard Carnot, and emphasizing mathematical formalism in its place. The political campaign to crush what remains of the republican faction at the *Ecole Polytechnique* reaches its highpoint with the appointment of the royalist Auguste Cauchy in 1816, but the methodological war has been raging since the early days of the *Ecole*.

With Napoleon's rise to power and the ensuing militarization of the *Ecole* in 1799, Laplace's power in the *Ecole* was greatly strengthened. At the same time, Laplace consolidated a system of patronage with which he and his friends could exercise increasing control over the scientific community. An important instrument was created with the Societé d'Arcueil, which was founded in 1803 by Laplace and his friend Berthollet, and financed in significant part from the pair's own private fortunes. Although the Societé d'Arcueil supported some useful scientific work, and its members included Chaptal, Arago, Humboldt, and others, in addition to Laplace and his immediate collaborators (such as Poisson and Biot), Laplace made it the center of an effort to perfect a neo-Newtonian form of mathematical physics, in direct opposition to the tradition of Fermat, Huyghens, and Leibniz. In contrast to the British followers of Newton, whose efforts were crippled by their own stubborn rejection of Leibniz's calculus, Laplace and his friends chose a more tricky, delphic tactic: use the superior mathematics developed from Leibniz and the Bernoullis, to "make Newtonianism work."

Augustin Fresnel

André-Marie Ampère



Newton's conception of the propagation of light. *Straight-line light rays—what could be simpler? According to Newton, the shadow changes only in size, linearly, with distance.*

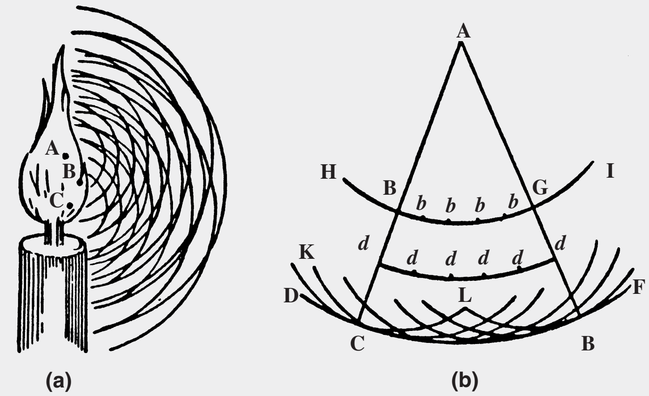
Poisson, whose appointment to the *Ecole Polytechnique* had been sponsored by Laplace and Lagrange, worked as a kind of mathematical lackey in support of this program. He was totally unfamiliar with experimental research, and had been judged incompetent as a draftsman in the *Ecole Polytechnique*. But he possessed considerable virtuosity in mathematics, and there is a famous quote attributed to him: "Life is good for only two things: doing mathematics and teaching it." An 1840 eulogy of Poisson gives a relevant glimpse of his personality:

"Poisson never wished to occupy himself with two things at the same time; when, in the course of his labors, a research project crossed his mind that did not form any immediate connection with what he was doing at the time, he contented himself with writing a few words in his little wallet. The persons to whom he used to communicate his scientific ideas know that as soon as he had finished one memoir, he passed without interruption to another subject, and that he customarily selected from his wallet the questions with which he should occupy himself."

Mathematical Theory of Light

In the context of Laplace's program, Poisson was put to work to elaborate a comprehensive mathematical theory of electricity on the model of Newton's *Principia*. Coulomb had already proposed to adapt Newton's "inverse square law" to the interaction of hypothetical "electrical particles," adding only the modification, that like charges repel and opposite charges attract—the scheme which is preserved in today's physics textbook as "the Coulomb law of electrostatics." Poisson's 1812 *Memoire* on the distribution of electricity in conducting bodies, was hailed as a great triumph for Laplace's program, and a model for related efforts in optics.

Indeed, between 1805 and 1815 Laplace, Biot, and (in part) Malus created an elaborate mathematical theory of light, based on the notion that light rays are streams of particles that interact with the particles of matter by short-range forces. By suitably modifying Newton's original "emission theory" of light and applying superior mathematical methods, they were able to "explain" most of the known optical phenomena, including the effect of double refraction, which had been the focus of Huyghens' work. In 1817, expecting to soon celebrate the "final triumph" of their neo-Newtonian optics, Laplace and Biot arranged for the physics prize of the French Academy of Science to be proposed for the best work on the theme of *diffraction*—the apparent bending of light rays at the boundaries between different media.



Huyghen's envelope construction for light. *Light starting out from any point forms wave fronts, which are like expanding concentric spheres. In these figures taken from Huyghens' "Treatise on Light," the wave fronts from points A, B, and C of a candle flame are pictured in (a). In (b), Huyghens shows how these waves can cooperate to form an "envelope" along the wave front DF, and how, along a radial line such as AC, they could have the appearance of a straight ray.*

In the meantime, however, Augustin Fresnel, supported by his close friend André-Marie Ampère, had enriched Huyghens' conception of the propagation of light by the addition of a *new physical principle*. Guided by that principle—which we shall discover in due course—Fresnel reworked Huyghens' envelope construction for the self-propagation of light, taking account of distinct *phases* within each wavelength of propagational action, and the everywhere-dense interaction ("interference") of different phases at each locus of the propagation process.

In 1818, on the occasion of Fresnel's defense of his thesis submitted for the Academy prize, a celebrated "showdown" occurred between Fresnel and the Laplacians. Poisson got up to raise a seemingly devastating objection to Fresnel's construction: If that construction were valid, a *bright spot* would have to appear in the middle of the shadow cast by a spherical or disk-shaped object, when illuminated by a suitable light source. But such a result is completely absurd and unimaginable. Therefore Fresnel's theory must be wrong!

Soon after the tumultuous meeting, however, one of the judges, François Arago, actually did the experiment. And there it was—the "impossible" bright spot in the middle of the shadow! Much to the dismay of Laplace, Biot, and Poisson, Fresnel was awarded the prize in the competition. The subsequent work of Fresnel and Ampère sealed the fate of Laplace's neo-Newtonian program once and for all. The phenomenon confirmed by Arago goes down in history with the name "Poisson's spot," like a curse.

The Subjectivity of Science

Before proceeding to work through the essentials of these matters, it is necessary to insist on some deeper points, which some may find uncomfortable or even shocking. Without attending to those deeper matters, however, most readers are bound to misunderstand everything we have said and intend to say in the future.

It is difficult, or even virtually impossible, in today's dominant culture, to relive a scientific discovery, without first clearing away the cognitive obstacles reflected in the tendency to reject, or run away from, the essential *subjectivity* of science. Accordingly, as a "cognitive I.Q. test," challenge yourself with the following interconnected questions:

(1) Identify the devastating, fundamental fallacies behind the following, typical textbook account:

"There were two different opinions about the nature of light: the particle theory and the wave theory. Fresnel and others carried out experiments which proved that the particle theory was wrong and the wave theory was right."

(2) Asked to explain the meaning of "hypothesis," a student responds:

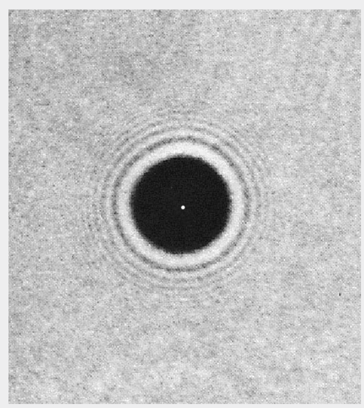
"An hypothesis is a kind of guess we make in trying to explain something whose actual cause we do not know."

Is this your concept? Is it right?

(3) What is the difference between what we think of as a property of some object, and a physical principle? Why must a physical principle, insofar as it has any claim to validity, necessarily apply to all processes in the Universe, *without exception?*

If you encounter any difficulty in answering the above, re-read in particular Lyndon LaRouche's discussion of the "Parmenides paradox," in his book-length essay, *Project A.*

—by Jonathan Tennenbaum



François Arago demonstrated experimentally that the "impossible" bright spot does, in fact, appear in the middle of the shadow cast by a spherical or disk-shaped object.