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Can "Goethean Physics" Contribute to a Better Understanding of Optics and Colorimetry?

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Introduction

A recent volume devoted to innovative approaches in educational physics - or, from a larger perspective, to STEM (Science, Technology, Engineering, and Mathematics) education [Fazio] proposes "curriculum models for our collective future". The main message of this collective work seems to be that the approach of the mainstream physics of our time should be reconsidered. One of the contributors, Prof. Gray from Aberdeen University, put a rethorical question and suggests an answer [Gray]: Can a rethinking of science education incorporate a much more phenomenological and experiential approach, with a particular focus on relations in the natural world, rather than reductive fragmentation of mainstream science? Can this go some way to creating a new vision of science that is good for the environment and even results in the transformation of the scientists themselves? Can science curriculum be organised to support this focus? Much of the literature around Goethean science suggests it can, notwithstanding caveats to some of the science that Goethe himself conducted and some of his thinking. Nevertheless, as has been argued, there are some very sound elements to the Goethean methodology that are, perhaps, appropriate for consideration for incorporation into mainstream science education. The only - more or less - elaborated part of the Goethean physics is the Goethean theory of colours, which is a variant of the Aristotle's theory of colours, as Goethe himself claims; so, in order to assess the adequacy of the Goethean physics we have to refer firstly to Aristotle's physics.

Aristotelian Physics

Aristotle's (Aristotelian) physics is exposed in four works: Physica, De Caelo, De Generatione et Corruptione and De Coloribus [Wiki]; the last one is essential for analysing Goethe's theory of colors [Goethe]. The latin word 'physica' - which gave the modern word 'physics' - means 'study of nature'; itself is a borrowing of the Greek φυσική (phusikḗ 'natural science'), a term derived from φύσις (phúsis 'origin, nature, property') [wiki-hist.phys]. Consequently, Aristotelian physics is not 'physics', in its modern sense, but 'study of nature'. This 'study of nature' does not include mathematics, which is not a 'natural science'. Out of its 23 centuries of existence, the appraisal of Aristotelian physics was high, until the centenial defined by the rising of Galilei (1564 - 1642) death of Newton (1642 - 1726); later on he remained, of course, important for the philosophy and history of science. Recently, its apprisal knew a quite unexpected revival, due to the contributions of two outstanding scholars, Monica Ugaglia and Carlo Rovelli. Monica Ugaglia noticed that the domain of excellence of Aristotle's physics is the movement of bodies imersed in fluids, in Earth' gravitational field. [Ugaglia]. As Rovelli notices - For a student who has learned physics in a modern school it may sound strange to start physics by studying objects in a fluid. But for somebody who hasn't it may sound strange not to: everything around us is immersed in a fluid [Rovelli].

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Actually, these were the bodies Aristotle used to study and whom movement tried to understand. Carlo Rovelli confronted the behaviour of solutions of equations of motion of bodies imersed in a fluid, in gravitational field, written in the formalism of Newtonian physics, to Aristotle's description, and get the following conclusion, which will probable became a milestone in the evaluation of scientific skills of the great philosopher [Rovelli]. Aristotle's physics is a highly nontrivial correct description of these phenomena, without mistakes, and consistent with Newtonian physics, in the same manner in which Newtonian physics is consistent with Einsteinian physics in its domain of validity (see also Moody, ref. [16] in [Rovelli]). The limitations of Aristotle's physics reflect mainly the limitations of contemporary mathematics: Quantitative precision is not very common in Aristotle, who is interested in the causal and qualitative aspects of phenomena [Rovelli]. And it couldn't be otherwise, in a scientific culture in which even the concept of function was not crystallized. If the movement of bodies - a part of mechanics, including several phenomena easily observable without any special device - could be corectly described by the great philosopher, his attempts to characterized the light and colors is a complete failure. To support this judgment, we shall reproduce some few fragments from Aristotle's writings: The intermediates are derived from the contraries - colours, for instance, from black and white.

This excerpt from Physica is an example of the tribute paid by a science without any experimental basis, to philosophy. Now, three excerpt from De Coloribus:

1) ...light is the colour of fire

2) So when what is black and shady is mixed with light the result is red.

3) ...all colours are a mixture of three things, the light, the medium through which the light is seen, such as water and air, and thirdly, the colours forming the ground, from which the light happens to be reflected.

All of them highlight the confusion between light and color, systematic in Aristotle's physics. Again, concerning the 3rd one: light is not necesserely produced by fire, but also by Sun, or other celestial bodies, by lightning, or fire flies etc. So, by no way the Aristotle's physics could produce a reasonable 'theory of colors'.

Newtonian Physics and Goethean Complexes

Mathematics would manifest itself spectacularly in physics barely 18 centuries after Aristotle. If at Galileo mathematics is still elementary, at Newton it is incomparably more difficult. In fact, Newton titled his first treatise. Philosophiæ Naturalis Principia Mathematica (Mathematical Principles of Natural Philosophy): he explicitly states that he studies the "philosophy of nature", expounded by Aristotle, using "mathematical principles". These principles will be able to quantitatively explain the movement of bodies in fluid environments and gravitational fields. Newton's second treatise, "Optics", is equally difficult: nothing in this fundamental opus is accessible to a reader concerned with light and colors, but ignorant of "mathematical principles". "Optics" was to complete, in a masterly manner, Newton's debut work, in which he studied the passage of light through a prism, The New Theory of Light and Colors. The acceptance of Newtonian physics by the contemporary scientific community was a complex process. Criticisms of Newton's work were initially made through the secretary of the Royal Society. Newton spent 6 months working on a reply to Hooke's criticisms of The New Theory of Light and Colors. The replies to Huygens are less elaborate, but in one of them Newton admits that he made a mistake when discussing the possibility of obtaining white light from mixing several colors.

In Germany, Leibniz manifested interest in Newton's theory and his disciple Christian Wolff championed it in a textbook published in 1710. In a review that Wolff probably wrote for the Acta eruditorum of 1713, "the extremely sagacious Mr. Newton" was prayed to "condescend to devote attention to the problem raised about his theory by the highly ingenious Mariotte." Newton "devoted attention" and Mariotte was satisfied with his answer. For Goethe, whose mathematical knowledge is derisory, the development of the study of nature in the direction opened by Newton - and followed with fascination by contemporary researchers - is tantamount to a ban. Goethe is attracted by natural philosophy, but repelled by mathematical principles. In his immeasurable pride, Goethe does not blame himself for his inadequacy in relation to mathematics, but blames mathematics, which he considers inadequate in relation to the study of nature. In order to move from concepts to persons, Goethe blames Newton (without ever having read him), guilty of the mathematization of natural philosophy. For Goethe, the mathematization of natural science is an expulsion from paradise [Bârsan]. Therefore, Goethe tries to forge his own path in the study of colors, trying to recreate Newton's experiments or propose new ones, and publishing a theory of colors, Zur Farbenlehre [Goethe]. As explicitly stated by Goethe, in the didactic part of Zur Farbenlehre, mathematics that try to grasp the secrets of nature appear to him as a kind of cabalistic symbols, typical of the Middle Ages.

Thomas Young, probably the most brilliant specialist in the science of colors of the beginning of the 19th century, finds in the Historical Part of Goethe's text, "some industry but little talent, and less judgement". He also carried out an experiment, described as "crucial" by Goethe, but he observed the opposite to what the poet had claimed to take place. Young's global perception is that Goethe's theory represents "a strange perversion of human faculties." This opinion is still the most quoted diagnosis of Zur Farbenlehre. Since "Goethean physics" demonizes mathematics, and its experimental support is either wrong (see Young) or extremely modest, it is impossible to fit it into any STEM approach. At the same time, its extremely aggressive language makes it practically unusable in an educational or academic environment. And, above all, it makes absolutely no contribution to scientific knowledge. If there is anything that makes it interesting, it is its pathological character [1-8].

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