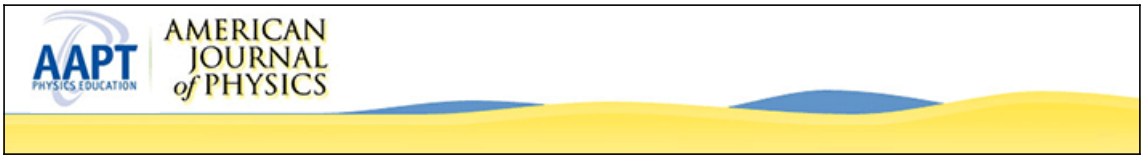

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Citation: American Journal of Physics **37**, 195 (1969); doi: 10.1119/1.1975444
View online: http://dx.doi.org/10.1119/1.1975444
View Table of Contents: http://scitation.aip.org/content/aapt/journal/ajp/37/2?ver=pdfcov
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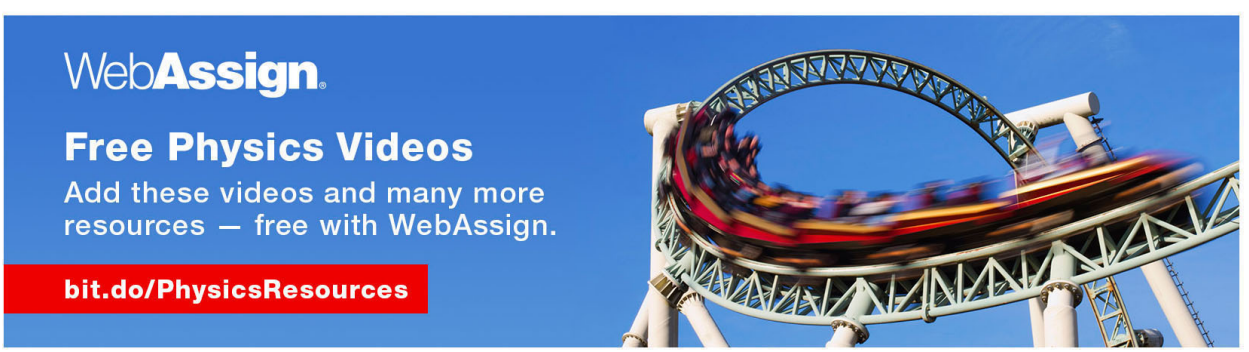

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AMERICAN JOURNAL OF PHYSICS VOLUME 37, NUMBER 2 FEBRUARY 1969

Goethe and the Physicists

STANLEY L. JAKI
Research Professor, History and Philosophy of Physics, Department of Physics, Seton Hall University, South Orange, New Jersey 07079
(Received 26 February 1968; revision received 19 August 1968)

In recent years several noted physicists suggested that renewed attention should be paid to Goethe, the author of the *Farbenlehre*, as this work may contain the clues for a satisfactory synthesis between the objective and the subjective. The paper gives a summary of their views, and probes into Goethe's motivations and procedures as regards his avid pursuit of the investigation of colors. The history of the reaction of physicists to the *Farbenlehre* suggests that its author can hardly be considered as a safe guide toward a culture surmounting the division between science and the humanities.

I. GOETHE IN AN AGE OF SCIENCE

An undoubtedly true sign of greatness is the persistent challenge that can be exercised by a person's thought or actions from the distance of generations, let alone centuries. Goethe is one of these persons. Not only men of letters but also scientists come across his towering figure on their intellectual journey. In an age of scientific specialization and of grave cultural splits, he looms large in the eyes of many as a universal man embodying balance and versatility. His activities were certainly most varied and relate to such different fields as literature, political administration, and last, but not least, science. It should not, therefore, be a surprise that during the last two decades or so, several leading German physicists suggested that a closer study of Goethe's ideas on science and colors in particular may well benefit our ailing, highly technological civilization.

The devastation of World War II was already engulfing much of the world when W. Heisenberg delivered a lecture on "The Teachings of Goethe and Newton on Colour in the Light of Modern Physics."[1] In it Heisenberg emphasized the cultural import of what in his view constituted Goethe's primary aim in investigations of colors, the *Farbenlehre*: the defense of the world of sense perception from the onslaught of the mathematical abstractness of physical research. As sense perception constitutes the eminently subjective realm of qualities, Goethe's primary aim can also be defined as the vindication of the subjective against the so-called objective realm of facts and procedures. In fact the outstanding Swiss physicist, W. Heitler, saw the deepest roots of Goethe's lifelong struggle against Newtonian optics in the correct realization by the poet that the line of separation between the objective and the subjective is often arbitrary and hard to define. This comment of Heitler on Goethe is in the second chapter of his perceptive study, *Man and Science*, devoted to a most urgent need: the forestalling of the further dehumanization of man by modern technology and by its spurious quantitative philosophy.[2] In Goethe's investigations on colors, Heitler saw convincing evidence that "it was quite possible to take the view that color belongs to the objective, external world."[3]

This last remark of Heitler was in substance echoed by Max Born, in his discussion[4] of Eckart Heimendahl's notable attempt[5] to give a systematic account of man's color perception from the physical as well as the psychological viewpoint including even the emotional symbolism of colors. Born, in fact, called on his fellow physicists to transcend the limitations of the quantitative

[1] W. Heisenberg, *Philosophic Problems of Nuclear Science*, translated by F. C. Hayes (Faber & Faber, London, 1952), pp. 60–76.

[2] W. Heitler, *Man and Science*, translated by Robert Schlapp (Basic Books, Inc., New York, 1963).

[3] See Ref. 2, pp. 24–25.

[4] M. Born, "Betrachtungen zur Farbenlehre," Naturwissenschaften **50**, 29–39 (1963).

[5] E. Heimendahl, *Licht und Farbe: Ordnung und Funktion der Farbewelt* (Walter de Gruyter, Berlin, 1961).

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method and to cultivate a receptiveness for those aspects of reality that are inaccessible to science. With specialization on the rampage, Born warned, the whole scientific enterprise has become a senseless undertaking with the result that the finest achievements of science are pushing man toward the brim of self-destruction. Therefore, as Born writes, "We should resume contact with Goethe and with those who keep cultivating and developing his thought," and especially "learn from them not to forget the meaning of the whole amidst the fascination of details."[6]

The indispensability of both details and of the whole constitutes also a principal theme in the reflections of Carl Friedrich von Weizsäcker on the cultural significance of Goethe's color theory. His ideas on this point can be found in his postscript to a recent edition of Goethe's scientific writings,[7] in his acceptance speech of the Goethe Medal in Frankfurt in 1958,[8] and in his foreword to Heimendahl's work.[9] Weizsäcker felt that a serious reflection on the conceptual framework of modern physics might open up possibilities to recover the primacy of wholeness, to develop a consistent type of language free from the source of much cultural evil, the Cartesian cleavage. According to him the dialogue between Goethe and modern physics was possible because both rested on a common ground which Weizsäcker epitomized in the phrase: "Plato and the senses."[10] For Weizsäcker the richness of the Platonic "idea" led to its subsequent bifurcation into form and concept, symbol and law, the unique and the general. Neither component of these pairs does, however, suffice. In one's grasping of the uniqueness of a particular experience it is man's urge for immediate wholeness that dominates. When appraised analytically things are divided, atomized, in order that a general statement may be formulated. The immediate wholeness is perceived as form (Gestalt), a category that is closely akin to Goethe's Urphenomenon, which constitutes the backbone of his philosophy and methodology of science. Goethe's timeliness, Weizsäcker argues, should now be evident. As the threat of atomic annihilation and global hunger are in a sense the consequences of man's weakened appreciation for wholeness and relatedness, it is highly imperative to probe into the deepest layers of Goethe's thought on science and especially on the most exact form of it, physics. It is to this task that we should now address ourselves.

II. GOETHE AND PHYSICS

To anyone familiar with both physics and literature it may be a source of giddiness to read what the great poet told Eckermann four years before his death: "As for what I have done as a poet I take no pride in it whatever.... But that in my century I am the only person who knows the truth in the difficult science of colors—of that, I say, I am not a little proud, and here I have a consciousness of superiority to many."[11] Surprising as it may be, this startling statement was not the effect of momentary impulse. Several years earlier, on December 30, 1823, he had already emphasized to Eckermann that for the previous 20 years he had been the only one to perceive that Newton and his fellow physicists were in decisive error about the true nature of colors.[12] Convinced of his epoch-making achievement, Goethe brushed aside all criticism for the rest of his life. His guiding principle remained what he had written in 1811 in the wake of the adverse reaction of physicists to the publication of the *Farbenlehre*: "These gentlemen [the physicists] may act as they wish, they shall not in the least eliminate this book from the history of physics."[13]

Actually, Goethe could have referred in his

[6] See Ref. 4, p. 39.

[7] C. F. von Weizsäcker, "Nachwort" in *Goethes Werke* (Wegner, Hamburg, 1948–1960), Vol. 13, pp. 537–554.

[8] C. F. von Weizsäcker, "Goethe und die Natur," Gegenwart **13**, 555–557 (Sept. 6, 1958).

[9] Reference 5, pp. vii–x.

[10] Reference 7, p. 538.

[11] J. P. Eckermann, *Gespräche mit Goethe in den letzten Jahren seines Lebens*, H. H. Houben, Ed. (F. A. Brockhaus, Leipzig, 1925), p. 261.

[12] Reference 11, p. 426.

[13] In a letter to F. A. Wolf, 28 Sept. 1811, in *Goethes Sämtliche Werke* (Georg Müller Verlag, Munich, 1909–1932), Vol. 23, p. 129.

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remarks to Eckermann not to 20 but to 40 if not 50 years. From his student days Goethe was under the influence of factors that gradually built up in him a frame of mind unreceptive to the conceptual world of Newtonian or classical physics and in particular to its discussion of colors. First there was his encounter during his university years with Baron d'Holbach's *Système de la nature*, the perfect embodiment of the nightmare of a consistently "scientific" world view. Its reading left Goethe with a distinct revulsion against exact science as can be seen from his vivid account of his experience postdating it by some 40 years.[14] The exploitation of science by d'Holbach's scientism prompted the young Goethe to throw himself, to quote his words, "into living knowledge, experience, action, and poetising, with all the more liveliness and passion."[15]

Unfortunately, it was not only poetry and social life that served for Goethe as a source of "living" knowledge. He found it also in alchemical writings, a dark field that hardly whets one's appetite for the clarity of mathematical physics. In addition, there was at work in young Goethe a secret frustration. Deep in his heart he wanted to excell as a painter but obviously he lacked talent. Gifted with a unique creative power in the field of poetry he felt no urge to write its theory. But he had to theorize about paintings and colors because, as he put it, he wanted to "fill up the deficiencies of nature by reason and insight."[16]

The moment for the release of his pent-up frustration came as he set foot on Italian soil. The resplendent colors of the landscape impressed him to the very core of his being, to say nothing of the impact made on him by the colorful canvasses of Italian painters. While in Rome he even persuaded a friend, an amateur painter, to try out his budding theories on colors. But the crucial event in the life of Goethe, the physicist, occurred on a day in January, 1790, when he was requested to return a borrowed prism that for months lay unpacked on his desk. On the spur of the moment, he decided to make a last-minute experiment with it. Contrary to his interpretation of the laws of Newtonian optics the whole wall facing the window did not turn into the hues of the rainbow. So he decided that Newton was wrong. It appeared to him as if an insurmountable barrier, the unquestioned supremacy of Newtonian optics, had been removed from his way, as if by magic. As he recorded the historic moment in the *Farbenlehre*, "I instinctively exclaimed Newton's theory is false."[17]

In the same passage Goethe also admits that he had no expertise in physical science and that he felt the need of professional advice. But when it was offered to him he turned deaf ears on the friendly and competent words of Georg Christoph Lichtenberg, professor of physics at Göttingen. Goethe's few valuable insights in botany and comparative anatomy only strengthened his self confidence as a physicist. He did not sense that something was wrong with his contentions when his two short "Contributions to Optics", published in 1791 and 1792, received a unanimously negative reaction on the part of physicists. The scientific journals treated him, so he claimed, with "haughty condescendence.... They reported my effort in such a way as to help it sink into oblivion forever."[18]

He decided to be his own guide in physics. When during 1792–93 he had to partake in the campaign against the French, he carried along Johann S. T. Gehler's four-volume dictionary on physics. When asked by Prince Reuss during the bombardment of Verdun what he had in mind, the great poet, according to his own account, "began to speak with great animation of the doctrine of colors."[19] It was with the same animation that he tackled the study of Newton's *Opticks* once the campaign was over. But it was not the spirit of docility that led him, the tyro, through the pages of that extraordinary book. He aimed

[14] J. W. von Goethe, *Truth and Fiction Relating to My Life*, translated by John Oxenford (John C. Nimmo Ltd., London, 1903), Vol. 2, pp. 108–110.

[15] Reference 14, p. 110.

[16] "Konfession des Verfassers," *Zur Farbenlehre. Historischer Teil*, Ref. 13, Vol. 22, p. 379.

[17] Reference 13, Vol. 22, p. 384.

[18] Reference 13, Vol. 22, p. 389.

[19] J. W. von Goethe, *Kampagne in Frankreich 1792*, Ref. 13, Vol. 34, p. 210.

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at its wholesale refutation. The literary result was the Polemical Part of the *Farbenlehre* which is characteristically enough left out time and again from most editions of his collected works though, without reading it, one cannot get a real feeling of the psychological abyss of Goethe's self deceit.

In that Polemical Part, Goethe charged Newton with obdurate resistance to the light of evidence (§§7, 230, 360, 553),[20] labeled him a Sophist (§582) and a bandleader of Cossacks (§178). He dismissed Newton's experiments as inaccurate and his formulas as inapplicable to facts (§10), characterized his method as a systematic evasion of the evidence (§96). He described Newton's theory of colors as a "pleasant tale" and an "empty illusion" (§205), his accomplishments in optics as "hocus-pocus" (§45), a "rubbish of words" (§635) and the worst example of shamelessness in the history of sciences (§360).

Physicists he spoke of as Newton's herd (§654). The mere thought of their existence turned him angry. He decried their obstinacy (§211), their eagerness to "cement, patch-up, and glue together, as witchdoctors do, the Newtonian doctrine, so that it could, as an embalmed corpse, preside in the style of ancient Egyptians, at the drinking bouts of physicists." (§471) He wished that Newton's followers should "wear special garments so that they could be distinguished from sane people" (§572). Sadly registering that "the world had believed for a hundred years this trickery of theirs" [Newtonian optics] (§113) he felt his urge justified "to tell all possible evil about them and their originator" (§675). His feeling of righteousness in this regard was so overwhelming that 20 years later when a publisher wanted to drop the Polemical Part from a planned edition of his collected works, Goethe most resolutely defended his vilification of Newton.[21]

In line with his overriding ambition Goethe wanted to know all that had been stated on colors from the pre-Socratics down to his time. The result of his voracious reading was presented as the Historical Part of the *Farbenlehre*. As could be expected, Goethe dwelt at great length on the ancients, the medievals and many a second-rate seventeenth- and eighteenth-century cultivator of optics and on their qualitative if not philosophical statements about light and colors. His attention, however, petered out as he approached the closing decades of the eighteenth century that saw physical optics grow more exact and robust. Obviously he could not bear the evidence mounting against him. It was these prejudices that vitiated the purpose of Goethe's remarkable observations of color-effects that comprise the first or Didactic Part of the *Farbenlehre*. It was offered by him as the new and only reliable form of the study of colors. In it mathematics could have no part whatever. After all, Goethe's main pride was to have demonstrated that a physics without mathematics was possible and indispensable. He never wavered in this conviction of his since he intimated it in his first paper published in 1791. Two decades later he recalled that one of the main reasons for its poor reception was that "nobody had any longer the faintest idea that a physics can exist independently from mathematics."[22]

He correctly diagnosed the consensus. No less correct were all the physicists who found themselves unable to reconcile the contradictions in that section of the *Farbenlehre* where Goethe states his views on the use of mathematics in physical science.[23] His had a frantic fear that mathematics destroyed the beauty and immediacy of observation. Observation meant for him an intuitive, poetic glance, or to use his favorite word, aperçu. He believed that only a reliance on aperçus unfettered by mathematics can discover and keep in view the form of things through which he believed their ultimate nature was shining forth. It was on these "ultimate natures" or Urphenomena that according to him rested the structure of nature whose dynamism was in turn regulated by various pairs of polarities. White light for Goethe was an Urphenomenon that should have never been analyzed into alleged parts. Colors were not parts of white light but the result of the interplay of two polarities, light and darkness. Moreover, he defined darkness not

[20] The numbers in parentheses refer to the paragraphs of the Polemical Part of the *Farbenlehre* as numbered by Goethe.

[21] Reference 11, p. 396.

[22] Reference 13, Vol. 22, p. 389.

[23] Reference 13, Vol. 21, pp. 184–186.

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as an absence of light, but a positive entity. Any not perfectly translucent medium contained in itself a share of darkness, and once light touched upon this "troubled medium" colors were produced.

It was this primitive if not obscurantist conceptual system that constituted the framework of the new physical optics (study of colors) as legislated by Goethe. Actually his bunglings merely showed that if there was any scientific way in which the beauty of nature could not be saved it was along the lines of the *Farbenlehre*. He could not even account for the Urphenomenon of colors, the rainbow. Its explanation along his own optics eluded Goethe all his life, though even during his last months he still sent "solutions" of it to his friend, Sulpice Boisserée, director of the Observatory of Munich.

Boisserée's reply was disappointing. He also knew that the previous 17 years had not witnessed any encouragement for the hope expressed to him by Goethe in 1815, five years after the publication of the *Farbenlehre*. "It will take fifty years before the *Farbenlehre* will be accepted; it is now only for the young unbiased men, with the others there is nothing to do, they sit up to their necks in their system."[24] Perhaps some physicists stuck to their system too rigidly. But they had the right to do so. Their system was a consistent one because it was limited. Of this limitedness their awareness rarely weakened. They were also aware that, contrary to Goethe's claim, neither physics nor physicists had to be blamed for the erosion of man's confidence in the qualitative aspects of the world. The culprit was a philosophy heedless of the limitations of physics and of its own premises. Only with these in mind can one understand the reaction shown ever since by physicists to the *Farbenlehre*.

III. PHYSICISTS AND THE FARBENLEHRE[25]

What Goethe wrote about the reception of his two early papers was also in store for the *Farbenlehre*. Among its supporters "there was not a single physicist."[26] German physicists who took up the subject in the 1810's and 1820's could at most commend the material of the Historical Part. For the "physics" of the *Farbenlehre* they had no time to waste. As one of them, H. W. Brandes of the University of Leipzig noted, Newton's *Opticks* needed as little defense as did the Copernican arrangement of planets or the inverse square law of gravitation.[27] On occasion their remarks turned the table on Goethe when, for instance, F. T. Poselger took the poet to task, that for all his emphasis on painting and painters, he failed to do justice to the greatest of them all—the Sun. "The Sun," Poselger wrote, "appears to us more Newtonian in mentality than Mr. Goethe would have it. And Newton was really the man to ferret out his artistic technique."[28] For all the personal touch in such comments, the physicists never paid back Goethe in kind for his invectives against Newton and his colleagues. E. L. Malus, the first major French physicist to discuss the *Farbenlehre*, displayed good psychology in noting that Goethe was not likely to make many converts precisely because of his excessive intolerance. "As he condemns indiscriminately all statements of the science of optics, it is not in his book that one should dare search for errors that Newton might have committed."[29]

Among British physicists the first to analyze in depth the *Farbenlehre* was Thomas Young. In addition to his historic demonstration of the wave-character of light, Young did pioneering investigations in the field of physiological optics and he had a thorough familiarity with the history of optics as well. To him the Historical Part of the *Farbenlehre* appeared to exhibit "some industry but little talent, and less judgment."[30] He also

[24] *Goethes Gespräche. Erster Teil*, in *Gedankausgabe der Werke, Briefe und Gespräche* (Artemis Verlag, Zurich, 1948–1954), Vol. 22, p. 797.

[25] There is an immense literature on Goethe's *Farbenlehre* listed in the standard Goethe bibliographies. In this article the discussion is confined to comments made on it by physicists of some stature.

[26] Reference 13, Vol. 22, p. 387.

[27] H. W. Brandes, "Farbe," in *Johann Samuel Traugott Gehler's Physikalisches Wörterbuch*, new edition by Brandes, Gmelin, Horner, and others (E. B. Schmickert, Leipzig, 1825–1845), Vol. 4, Part 1, pp. 39–131; see especially p. 67.

[28] F. T. Poselger, "Der farbige Rand eines durch ein biconvexes Glas entstehenden Bildes, untersucht, mit Bezug auf Herrn von Goethes Werk *Zur Farbenlehre*," Ann. Physik **37**, 154 (1811).

[29] [E. L. Malus], "Traité des couleurs par M. Goethe," Ann. Chim. **71**, 199–219 (1811); quotation on pp. 218–219.

[30] [T. Young], "*Zur Farbenlehre*. On the Doctrine of Colours," Quart. Rev. **10**, 427–441 (1814); quotation on p. 429.

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carried out an experiment, described as "crucial" by Goethe against Newton, but he observed the opposite to what the poet had claimed to take place. Young also emphasized that Goethe's procedure presented a graver threat to the reality of colors than did the Newtonian approach. But most significantly Young called attention to the cultural debacle that would follow if one were to take seriously a work whose demonstrative value was equal to that of the "almanack of muses [full] with epigrams and satires."[31]

It was only a quarter of a century later, in 1840, that another British physicist of stature took up the matter. David Brewster, who earned his name mainly by his contributions to optics, joined the battle following the translation into English of the Didactic Part of the *Farbenlehre*.[32] He saw a major threat arising from it, not so much to the "edifice of Inductive Philosophy," but rather to culture in general. He was in particular concerned by the claim expressed by the translator and shared by those admirers of Goethe who admitted the indefensibility of the physics of the *Farbenlehre*, that "the experiments and views of Goethe are more applicable to the theory and practice of painting than the doctrines of Newton and his followers."[33] To Brewster, acceptance of such a claim was tantamount to a cultural disaster, to "placing the principles of art in direct alliance with error."[34] With these words he touched on the heart of the matter. To admit the scientific nullity of the *Farbenlehre* as a theory of optics, and to claim it as the true theory of art, was not only a strategy contrary to Goethe's intentions. It also meant giving respectability to a mentality for which "the slightest resemblances, the most fortuitous associations, are linked together as cause and effect." But as Brewster bluntly put it, it was the sacred duty of scientific thinking to protect culture from the mirage of what he aptly called cabalistic formulas.[35]

The next important physicist to weigh the merits of the *Farbenlehre* was Hermann von Helmholtz. His two discussions of the matter separated by a span of 40 years bring us face to face with a specifically German aspect of the problem. It seems that since the resurgence of German national pride in the 1840's a vindication of the honor of the author of the *Farbenlehre* has become a sacred cause to which German physicists feel dutybound to volunteer their stature and eloquence. Not that German patriotism could derive much comfort from Helmholtz's first address delivered on January 18, 1852, then Coronation Day in Prussia, before the Königsberg branch of the prestigious Deutsche Gesellschaft. As the lecture is widely available in English translation[36] no summary will be made here of Helmholtz's devastating criticism of Goethe, the physicist. The concluding part of the address which bears on the cultural relevance of Goethe the scientist should, however, be singled out. According to Helmholtz, Goethe's devotion to ideal beauty and culture had a very serious shortcoming. It led him to disregard a part of reality, the reality of the backstage consisting of levers, cords, and pulleys. That the sight of the backstage was ugly as compared to the colorful glitter of the artistic performance itself, Helmholtz readily admitted. Yet the machinery of the backstage, or the machinery of the physical world, constituted a reality that man could ignore only at the price of bringing on himself the collapse of civilization. Helmholtz tried to impress this on the humanistic segment of his audience in words that are worth being quoted in full: "We cannot triumph over the machinery of matter by ignoring it; we can triumph over it only by subordinating it to the aims of our moral intelligence. We must familiarize ourselves with its levers and pulleys, fatal though it be to poetic contemplation, in order to be able to govern them after our own will, and therein lies the complete justification of physical investigation, and its vast importance for the advance of human civilization."[37]

[31] Reference 30, p. 428.

[32] *Goethe's Theory of Colours*, translated by Charles Lock Eastlake (London, 1840).

[33] [D. Brewster], "Goethe's Theory of Colours," The Edinburgh Rev. **72**, 99–131 (1840); quotation on p. 99.

[34] Reference 33, p. 100.

[35] Reference 33, p. 122.

[36] H. von Helmholtz, "On Goethe's Scientific Researches," in his *Popular Scientific Lectures*, selected and edited with an Introduction by M. Kline (Dover Publications, Inc., New York, 1962), pp. 1–21.

[37] Reference 36, p. 20.

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Forty years later Helmholtz's tone was notably different. In an address delivered in Weimar at the invitation of the Goethe Society, Helmholtz dwelt at length on what is common between the aspirations of the scientist and the artist. This was unquestionably a skillful approach, through which one could extol Goethe as an apostle of culture and still be left with room to vindicate physics. To develop the former theme was Helmholtz's chief concern, and it led him astray on several points concerning the history of physics. Thus he claimed that the latest developments in the conceptual foundations of physics indicated a rapprochement toward Goethe's preference of the "concrete." As an example, he referred to the growing disfavor in physics for such "abstract" notions as force. He attributed Faraday's success in physics to his sense of the concrete unspoiled by mathematical abstractions. Helmholtz also felt that Huygens' wave theory of light as opposed to the corpuscular (Newtonian) theory was much akin to the Goethean Urphenomenon. Evidently, it was impossible for Helmholtz to finish his address without asserting himself as a physicist. As his lecture drew to an end, Helmholtz restated the indispensability of the inductive, quantitative method of physics and dismissed Goethe, the physicist. "In areas where only the use of inductive method could have helped him, Goethe ran aground."[38]

And so Helmholtz stopped short of doing precisely that against which a distinguished British physicist, A. Schuster, had warned a few years earlier in speaking about Goethe: "We shall not render his memory a service if we convert our admiration for him into idolatry, and bend our knees to his foibles as well as to his strength."[39] In spite of its shortness, Schuster's paper, a true gem in the vast literature on the *Farbenlehre*, brings out more lucidly than many longer discussions the crucial reasons for Goethe's error The *Farbenlehre* renounced the quantitative analysis of light and colors while claiming to offer a *full* treatment of colors. Another point Schuster emphasized was Goethe's uncritical trust in the reality of the commonsense world. This attitude of Goethe harked back to some basic principles of Aristotle's organismic physics, and the *Farbenlehre* was in more than one sense an effort to turn the clock of scientific history back by several hundred years. Needless to say, such a step can hardly be considered as culturally beneficial, though as Schuster aptly noted, there were still many admirers of Goethe who thought that in the *Farbenlehre* he "may have sown a seed which will bring forth good fruit hereafter."[40]

Possibly such a hope animated Thomas Carlyle. In May, 1878, he had presented John Tyndall, Faraday's successor at the Royal Institution, with a copy of the original edition of the *Farbenlehre*. It was a gift of Goethe to Carlyle, the rising young literary critic who did so much to spread the poet's fame abroad. Carlyle was now speaking of his wish that Tyndall, the noted physicist examine the volume and set forth what it really contained. Tyndall obliged to what meant for him a second look at the *Farbenlehre*. Following an earlier perusal of the work he had laid it aside with the conclusion that "Goethe in the *Farbenlehre* was wrong in his intellectual and perverse in his moral judgments."[41] His second study of it presented him with no reason to change his first conclusion. In a lecture delivered at the Royal Institution in March, 1880, Tyndall gave a detailed account of the principal points of Goethe's color theory, of its main errors, and of its merits as well. Some of these were cultural but, as Tyndall emphasized it, of rather limited value. As he correctly diagnosed the case, Goethe failed to understand the spirit of tolerance and pluralism which nature is capable of exhibiting when she inspires both poets and scientists.[42]

This spirit of tolerance, the readiness to rec-

[38] H. von Helmholtz, "Goethes Vorahnungen kommender naturwissenschaftlicher Ideen," Deutsche Rundschau **72**, 115–132 (July–Sept. 1892); quotation on p. 132.

[39] A. Schuster, "Goethe's *Farbenlehre*," in *Publications of the English Goethe Society, No. 5., Original Papers* (David Nutt, London, 1890), 141–151; quotation on p. 141.

[40] Reference 39, p. 141.

[41] J. Tyndall, "Goethe's *Farbenlehre*—(*Theory of Colours*)," The Popular Science Monthly **17**, 215–224, 312–321 (1880); quotation on p. 215.

[42] Reference 41, p. 321.

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ognize the irreducible plurality of aspects that make up the fullness of man's search for understanding, was not Goethe's strong side. As Arthur Sommerfeld noted in a thoughtful essay,[43] Goethe was dominated by an irresistible proclivity to take for real only that which was beautiful. Though undoubtedly a great friend and a most sympathetic observer of nature, Goethe did not possess the temper and qualities of a systematic investigator of nature. A similar point was emphasized a few years later by another prominent physicist at the University of Munich, Wilhelm Wien, a Nobel laureate.[44] According to him, Goethe, imbued with pantheism, felt confident that his genius could establish an intuitive contact with the world-spirit and gain thereby an all-embracing knowledge of nature. Thus while Goethe emphasized the observation of nature, he rejected systematic, laborious, carefully controlled experimentation about the details of nature. Such was a stance diametrically opposite to the spirit of physical science and Wien felt impelled to state: "High as Goethe stands in the esteem of physicists, the dictates of the goddess [the spirit of science] stand higher than those of even the most important mortal."[45]

But important he was—culturally, that is. And so Wien with a baffling inconsistency went on to finish his lecture with assertions on the cultural significance of Goethe in an age of science. It was a strange effort on the part of Wien who in the same lecture minced no words in deploring Goethe's inattention to the limitations of human intellect, however brilliant, and to man's inability to wrest the secrets of nature through one single masterstroke. Wien could hardly sound convincing to anyone who had already agreed with his carefully documented remarks on Goethe's ghastly misconceptions about physics and scientific method. Yet Wien claimed that some of Goethe's remarks on the relation of physics and philosophy were truly remarkable. He claimed that Goethe's Urphenomena and the fundamental laws and concepts of physics were akin in character. It was ironically fitting that he should offer a truly enigmatic illustration to a puzzling claim. In a staggering remark about magnetism, which Goethe considered an Urphenomenon, Wien stated that although electricity gives rise to magnetism, the latter is different in "nature" from the former. Again, one wonders if Goethe's cultural stature was enhanced by Wien's assertion that Goethe was not altogether wrong about the sometimes pathological nature of experimental physics, as even theoretical physics was not without some pathological aspects of its own. Finally, and contrary to Wien's claim, physicists did not need *Goethe's* faith in nature and in man to press on with confidence in their arduous search for the laws of nature. They did their work and are still doing it regardless of Goethe and his alleged significance for a cultural unity in an age of science.

As proof of this one need only read Weizsäcker's, Heitler's, Born's and Heisenberg's words on Goethe. On one specific point they all are in agreement: Goethe's dabbling in physics is not physics and under no circumstance should physics consult Goethe the physicist. As to their contention about the cultural relevance of Goethe in the atomic age, one could only wish that they had in mind the real Goethe and not an abstraction of him. The real Goethe did not understand the true nature of exact sciences and their crucial role in modern culture. He was much more at home in the sentimental estheticism of Weimar than in the cruelly muscular world of rising industrialism. To be sure, neither of these milieus represented a healthy solution. The former could not be maintained for too long; the latter could not be escaped any longer. But this is what Goethe tried to do, and in his frustration he laid the blame on Newtonian physics for cultural diseases for which the responsibility lay not in

[43] A. Sommerfeld, "Goethes Farbenlehre im Urteile der Zeit," Deutsche Revue **42**, 100–107 (1917). Sommerfeld gives an appreciative account of Goethe's original observations about color effects. Characteristically enough Sommerfeld's paper was prompted by his anxiety lest a group of painters in Munich should mislead the Ministry of Education by their insistence on the superiority of Goethe as "color-physicist" over Helmholtz, who, according to the group, did not know "light-energetics."

[44] W. Wien, "Goethe und die Physik," in Wilhelm Wien, *Aus dem Leben und Wirken eines Physikers* (Ambrosius Barth, Leipzig, 1930), pp. 79–102. Wien's lecture was given on 9 May 1923.

[45] Reference 44, p. 87.

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science but in scientism. To overcome the reductionist atmosphere of scientism he offered a reductionism in reverse in which esthetics dominated everything. He failed to see that the tension between the realm of qualities and quantities is an irreducible one which shall not disappear by shortchanging one realm or the other. Esthetical reductionism had few more persuasive if not seductive spokesmen than Goethe. But precisely because of this, in an age so dependent on the proper and unreserved use of science, Goethe cannot be looked upon as a reliable guide toward a truly human culture willing to render its due to quantities as well as qualities.

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