Gustav Mie: the person

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About 25 years ago, when I became acquainted with the name Gustav Mie, I was unable to find an entry for him in such major encyclopedias as the *Britannica* or even in several listings of famous scientists [T. I. Williams, *A Biographical Sketch of Scientists* (Wiley, New York, 1967); J. Turkevich and L. Turkevich, *Prominent Scientists of Continental Europe* (Elsevier, New York, 1968)]. This puzzled me indeed when I considered that Mie's 1908 paper and the terms Mie scattering and Mie effect were and continue to be copiously cited in the literature on particle light scattering. One can find few issues of *Applied Optics, the Journal of Aerosol Science, Aerosol Science and Technology,* and many related publications that do not mention Mie. Yet he is a shadowy figure, almost a disembodied three-letter name without much real existence. Within this biographical note, I try to put some flesh and bones on that apparently ghostly scientist.

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Gustav Adolf Feodor Wilhelm Ludwig Mie was born in 1868 in the northern German city of Rostock. He died at the ripe old age of 89 in 1957 in Freiburg im Breisgau.

In a brief autobiographical sketch written in 1948,[1] he states that he descends from Protestant pastor families on both his father's and mother's side and that his un-Germanic family name originated in 16th century Huguenot France from which his forefathers fled religious persecution. Ironically, the only entry on Mie that I eventually found in a dictionary of famous scientists[2] erroneously states that he was the son of a pastor. Mie himself informs us that his father was a kaufmann, a merchant, although his two grandfathers as well as several of their predecessors had indeed been clergymen. In the 17th century his mother's family was also driven by religious intolerance from Austrian Salzburg into German Württemberg. He had three brothers (one became a pastor in Scharnebeck) and a sister.[3]

Mie spent his early years in the old Hanseatic port of his birth in a traditional religiously oriented family environment, which initially appeared to lead him toward the study of theology. At the age of 16 he confronted, for the first time, the intellectual conflict between his strong religious upbringing and the scientific challenges of Haeckel and Darwin. Although the lure of a career in the exact sciences prevailed by the time of his high school graduation, Mie's strong religious beliefs persisted and influenced his work throughout his long life. He also asserts that Kant's *Critique of Pure Reason* had a long-lasting influence on his thoughts and that he literally banged his head repeatedly against a wall to master the more knotty passages of that treatise.

His first two years of higher education were spent at the University of his native Rostock. In 1888, he sought a broader academic environment by transferring to the renowned University of Heidelberg where he concentrated on mathematics and mineralogy. Mie states in his autobiographical notes that, although he was by then keenly interested in physics, theoretical courses in that field were still not available at Heidelberg or at most other major German universities of the time.

With characteristic dedication he immersed himself in various physics textbooks during vacations in Rostock so that by 1890 he could apply for the so-called State Examination for Mathematics and Physics. He was assigned to prepare a dissertation on each subject. He describes how he spent several months writing the physics assignment and was left with one day to prepare the mathematics thesis. He did so by working 24 hours with minimal interruption. Afterward he was accepted for the verbal examination in Karlsruhe in the Spring of 1891. Later the same year he obtained a doctorate with a dissertation on a "Very abstract problem of partial differential equations."[1] For a few months in 1892 he taught mathematics and natural sciences at a private school

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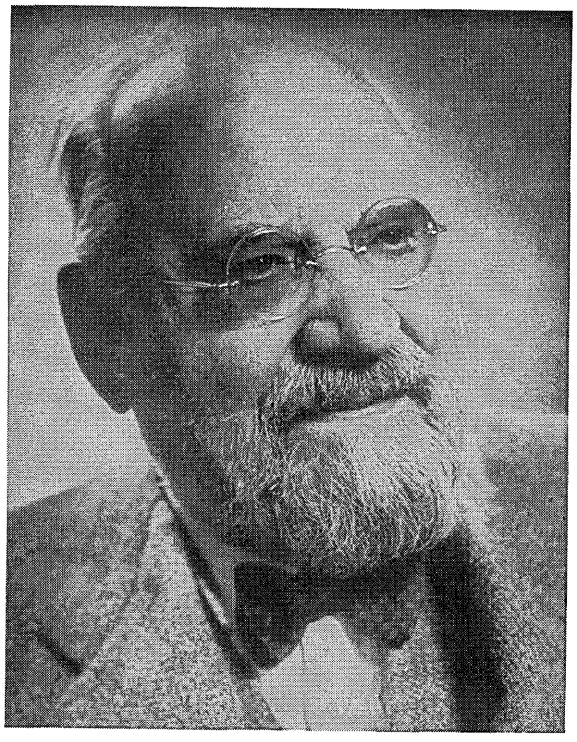

Fig. 1. Gustav Mie (photograph courtesy of H. Spehl, Albert-Ludwigs-Universität).

in Dresden. From there he sent a copy of his doctoral thesis to his old physics professor, Otto Lehmann, at the Technische Hochschule in Karlsruhe. He promptly gave Mie an assistantship to lead the physics laboratory training (*physicalisches Praktikum*), and shortly after this he was called to help in the preparation of experimental lecture demonstrations. Concurrently, he worked on the replication of the electromagnetic experiments of Heinrich Hertz. He used the actual instruments developed by that scientist some 5 years earlier, which were part of the collection of the Karlsruhe Physics Institute. He was required, however, to solidify his theoretical physics background to obtain the lectureship (*Habilitation*) that he received in 1897. Mie attributes his first widespread recognition by the scientific community as a theoretical physicist to a paper on the propagation of electric fields along two parallel conductors,[4] which was published around that time.

In 1901 he married Berta Hess (1875–1954),[3] whom he met during his Heidelberg days, and the subsequent year he assumed a special professorship post (*Extraordinarius*) at the University of Greifswald, not far from and to the east of his native Rostock. At Greifswald he wrote his paper on particle light scattering that made him famous. It is worthwhile to ponder the origin of that paper,[5] which was published in 1908 in the *Annalen der Physik,* bearing the title "Beiträge zur Optik Trüber Medien, speziell kolloidaler Metallösungen (Contributions to the optics of turbid media, especially colloidal metal suspensions)." Paradoxically, the importance of the 69-page paper appears to have been greatly underestimated by both its author and contemporary scientists. Indeed, Mie mentions neither this paper nor any of his investigations on light scattering by small particles in his autobiographical notes. Mie considered that his salient contribution to science was a textbook on electricity,[6] first published in 1910, in which he prides himself on having been able to describe Maxwell's theory on electromagnetic propagation without the use of equations, a somewhat paradoxical endeavor considering that his 1908 paper on particle scattering contains no less than 102 sets of equations. How familiar are many of today's scientists with the actual content of this paper beyond the customary ritual of using it as a reference? Its translation into English from its original German has not had wide circulation, and, as the above-mentioned mathematical content suggests, it was not intended for superficial browsing.

It appears, at least to me, that Mie's 1908 paper represents a single major involvement with the subject of particle light scattering and absorption. It was triggered (as suggested by Kerker[7]) by the experimental investigations on colloidal gold suspensions by a student (Walter Steubing) at the Greifswald Institute, to which Mie refers in the introduction to that paper. Steubing's dissertation was published in the *Annalen der Physik*[8] a few months after Mie's paper with the title "Über die optischen Eigenschaften kolloidaler Goldlösungen (On the optical properties of colloidal gold suspensions)." The author acknowledges his mentor's role as follows: "To conclude, I would like to express my heartfelt gratitude to Prof. Mie, on whose suggestion I undertook this work, for his steadfast and friendly interest and for his kind advice."

It is noteworthy that the analysis presented in Mie's paper is restricted to particle diameters up to 0.18 μm, a limit possibly related to Steubing's gold colloids. Thus we may speculate that Mie decided to develop a rigorous theoretical interpretation of the empirical results obtained by that researcher, which were based on Maxwell's equations on whose physical ramifications Mie had concentrated his attention since at least 1896. Here, at Greifswald, the noted resident Maxwellian specialist was called on to extend that theoretical framework to include the interaction of electromagnetic waves and particles whose size approaches the length of these waves. He proceeded, however, beyond the original intention of merely explaining the colors of colloidal gold observed by Steubing. But there it rested, and the last of the conclusions in this extensive paper states: "The thorough understanding of the theory will require the study of the behavior of ellipsoidal particles." Mie was to live for another half-century without publishing any additional material on particle light scattering.

Mie pursued his work at Greifswald over a period of 15 years, which he characterized as happy and scientifically productive. He singles out a major endeavor

that engaged him at Greifswald: his unsuccessful attempt at developing a comprehensive Theory of Matter, wherein Maxwell's equations were to be considered as limiting cases of a more general theory, based on the overall concept of a world-ether (Weltäther) consisting of the matter–energy continuum wherein elementary particles (i.e., atoms) are to be considered as energy nodes.[9–11] This pursuit was, as Mie suggests, inspired by the theory of relativity, which drew his attention for many years hence and remained a subject that he was to write about extensively.[12]

He recounts with nostalgia that during his Greifswald years, and until the onset of World War I, every March he joined the well-known physicist Wien at his alpine retreat for cross-country skiing excursions. They were joined by other outstanding German and Dutch Physicists, such as Sommerfeld, von Laue, and Debye.

In 1917 he received an offer from the University of Halle where he stayed until 1924. These were turbulent years in that city, which was disrupted by leftist revolts, rightist military takeovers, sieges, and pitched battles, all followed by rampant inflation. Nevertheless, Mie enjoyed his stay at Halle whose environment of interdisciplinary cross fertilization he found intellectually stimulating. In the spring of 1924 he was invited to join the faculty at the University of Freiburg im Breisgau in southwestern Germany where he spent the rest of his academic life. In 1935 he retired from lecturing and received the title of Professor Emeritus. In Freiburg he cofounded a scholarly society called the Pentathlon (because of the five extant faculties at the University of Freiburg), which, however, was dissolved shortly after Hitler came to power, since one of the other two cofounders was the Jewish philosopher, Jonas Cohn, who had to flee Germany.

He bemoans the difficult times under Hitler, followed by World War II, and "for us Germans, its deplorable ending." In Mie's defense, he seems to have been, if not explicitly anti-Nazi, at least detached from the pseudoscientific hysteria of the German Physics of that period.

He spent the last years of his life in quiet but intellectually active retirement in Freiburg as a senior patriarch of the physics community of his country. He was honored by his colleagues at the University and participated in Protestant church-related gatherings against the backdrop of a predominantly Catholic community. This religious involvement had accompanied his entire professional life and probably led him to pursue all-encompassing and transcendental theories of matter and energy that were compatible with his religious views. Several of Mie's writings in the 1930's and 1940's were published under the title "The Divine Order in Nature," where he advocated a synthesis between Christian beliefs and the natural sciences.[13]

Mie's main contributions to science, in addition to his oft-cited light-scattering paper, require recognition. He derived inductively the Maxwellian edifice from the empirical reality, a pursuit that still occupied Mie in his 80th year when the last and revised edition of his *Handbook of Electricity and Magnetism* was published.[14] His persistent search for a unified theory encompassing field and matter, although unsuccessful, nevertheless stimulated the work of other notable physicists such as Born[15] and Infeld. Other important pursuits by Mie included research into the dielectric constants of various materials using electromagnetic waves; the solution of the problem of the anomalous dispersion of water leading to the determination of the characteristic dielectric constant of that liquid; and x-ray crystallographic studies of hydrated naphthalenes, anthracenes, and polyoxymethylenes and of liquid crystals.

Mie, the person, appears to have been a gentle and avuncular savant, who was respected by his peers and led a largely noncontroversial, secluded, and somewhat isolated life. Even during the apogee of his academic career he remained on the periphery of the university environment, without the expected entourage of graduate students and doctoral candidates that surround the archetypal Herr Professor. One of his assistants wrote on the occasion of Mie's 100th anniversary[16] that he had been "a profound thinker, a notable researcher and a kind human being."

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