Kaluza, Theodor Franz Eduard | Encyclopedia.com

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(*b*. Ratibor, Germany [now Raciborz, Poland], 9 November 1885; *d*. Göttingen, Germany, 19 January 1954)

mathematical physics.

Theodor Kaluza was the only child of the German Anglicist Max Kaluza, whose works on phonetics and Chaucer were widely read in his day. The Kaluza family tree may be traced back to 1603, the family having been in Ratibor for over three centuries.

Kaluza was a bright student at school. Beginning his mathematical studies at the age of eighteen at the University of Königsberg, he prepared a doctoral dissertation on Tschirnhaus transformation[1] under Professor F. W. F. Meyer and qualified to lecture there in 1909. He married in the same year and remained a meagerly remunerated privatdocent in Königsberg for two decades.[2]

By the time Kaluza was past forty, Einstein, recognizing his worth and finding him in a position far below his merits, recommended him warmly for something better.[3] At last, in 1929, Kaluza obtained a professorship at the University of Kiel. In 1935 he moved to the University of Göttingen, where he became a full professor. Two months before he was to be named professor emeritus, Kaluza died after a very brief illness.

By the close of the nineteenth century, the concept of ether had become an integral part of physics. It was generally expected that the ether, and perhaps even the electromagnetic equations themselves, would explain all of physics, including gravitation. But when Einstein developed his general relativity theory (1910–1920), in which gravitational effects are traced to changes in the structure of a four-dimensional Riemannian manifold, the question arose as to whether the electromagnetic field could be incorporated into such a manifold. The aim was to give a unified picture of the gravitational and electromagnetic phenomena. This was referred to as the unitary problem.

Kaluza’s essentially mathematical mind was attracted to the problem. He initiated a line of attack by introducing into the structure of the universe a fifth dimension which would account for the electromagnetic effects. When he communicated his ideas to Einstein, the latter encouraged him to pursue such an approach, submitting that this was an entirely original point of view.[4] Kaluza’s major paper on this question appeared in 1921.[5] Here he combined the ten gravitational potentials, which arise in Einstein’s general relativity theory as the components of the metric tensor of a four-dimensional space-time continuum, with the four components of the electromagnetic potential. He did this by means of his fifth dimension, which had the characteristic restriction that in it the trajectory of a particle is always a closed curve. This makes the universe essentially filiform with respect to the fifth dimension.

Mathematically, the five-dimensional manifold may be defined in terms of the metric $d\sigma^2 = \gamma^{mn} dx^m dx^n$ $(m, n = 1, 2, 3, 4, 5)$,

in which the coefficients γ^{mn} are assumed to be independent of the fifth coordinate x^5. With the additional restriction that γ^{55} is a constant, Kaluza could deduce that the charge-mass ratio is a constant for the electron. The motion of electrically charged particles in an electromagnetic field is described by the equations of the geodesics in such a space.

If one were to assume that the periodicity of the fifth dimension is a “quantum effect”—indeed, that it is the physical source of Planck’s constant—then the radius of the curves in the fifth dimension which would give the empirical value of the electron’s charge would be on the order of 10^{-30} cm, and would thus be beyond the reach of experiment. (This result is due to O. Klein.

Kaluza’s theory was criticized on the ground that the fifth dimension is a purely mathematical artifice, with only a formalistic significance and no physical meaning whatever. Nevertheless, the five-dimensional idea was explored by several mathematical physicists.[6]

Kaluza also worked on models of the atomic nucleus, applying the general principles of energetics. He wrote on the epistemological aspects of relativity and was sole author of or collaborator on several mathematical papers. In 1938 a text on higher applied mathematics written by Kaluza and G. Joos was published; in this work he showed himself as a mathematician rather than as a mathematical physicist.[7]

Kaluza was a man of wide-ranging interests. Although mathematical abstraction delighted him tremendously, he was also deeply interested in languages, literature, and philosophy. He studied more than fifteen languages, including Hebrew, Hungarian, Arabic, and Lithuanian. He had a keen sense of humor. A nonswimmer, he once demonstrated the power of theoretical knowledge by reading a book on swimming, then swimming successfully on his first attempt (he was over thirty when he performed this feat). Kaluza loved nature as much as science and was also fond of children.

He was liked and respected by his students and had extremely good relations with his colleagues. He never used notes while lecturing, except on one occasion, when he had to copy down a fifty-digit number which showed up in number theory.

NOTES

1. The dissertation was published in *Archiv der Mathematik und Physik*, **16** (1910), 197–206.

2. Privatdocents did not have a definite salary; they were merely allowed the privilege of giving lectures. If a privatdocent gave *x* hours of lectures a week and had *y* students, he would earn about 5 *xy* gold marks per semester, an inconsiderable sum.

3. In a note written to a colleague in November 1926 Einstein praised Kaluza's "schöpferische Begabung." He considered it unfortunate that "Kaluza unter schwierigen äusseren Bedingungen arbeitet" and added, "Es würde mich sehr freuen, wenn er einen passenden Wirkungskreis bekäme."

4. In his first reaction to Kaluza's private communication of the five-dimensional idea, Einstein wrote, ". . . der Gedanke, dies (elektrischen Feldgrössen) durch eine fünfdimenstionale Zylinderwelt zu erzielen, ist mir nie gekommen und dürfte überhaupt neu sein. Ihr Gedanke gefällt mir zunächst ausserordentilch" (letter dated 21 Apr. 1919).

5. "Zum Unitärsproblem de Physik," in *Sitzungsberichte der Preussischen Akademie der Wissenschaften*, **54** (1921), 966–972. The communication was delivered by Einstein on 8 December 1921.

6. The most important of these were O. Klein, L. de Broglie, Einstein, E. P. Jordan, and Y. R. Thiry. For a detailed bibliography on these extensions the reader may consult the treatise by Tonnelat cited in the bibliography.

7. *Höhere Mathematik für die Praktiker* (Leipzig, 1938).

BIBLIOGRAPHY

I. Original Works. A bibliography of Kaluza's works is found in Poggendorff, VIIA, pt. 2 (1958), 684. I am indebted to Theodor Kaluza, Jr., for letting me see the scientific correspondence of his father, especially that with Einstein, and for relating personal details.

II. Secondary Literature. Good discussions of Kaluza's five-dimensional theory may be found in P.G. Bergmann, *An Introduction to the Theory of Relativity* (New York, 1942); and M. A. Tonnelat, *Les théories unitaires de l'sélectro-magnétisme et de la gravitation* (Paris, 1965).

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