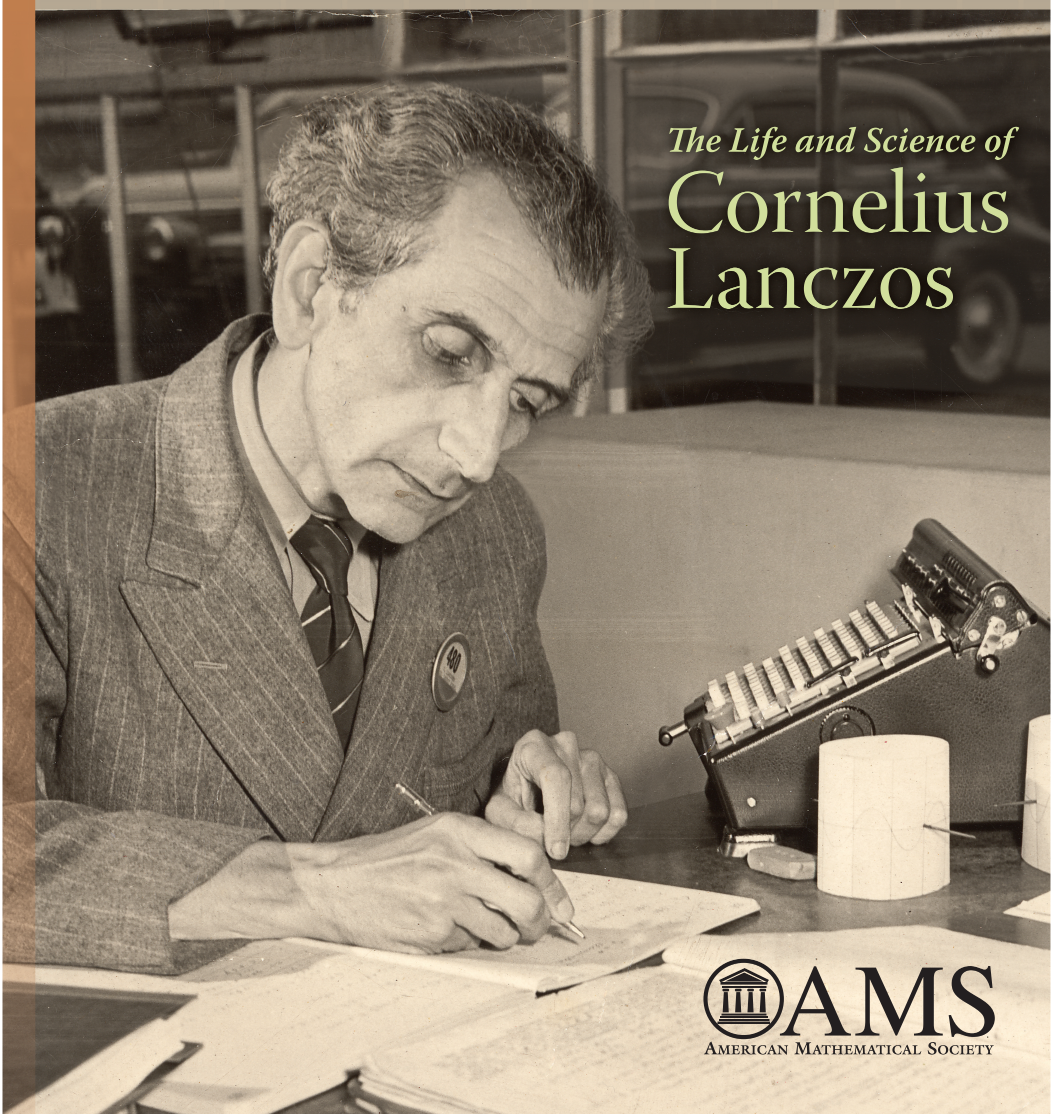
BARBARA GELLAI

The Intrinsic Nature of Things



The Life and Science of Cornelius Lanczos

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BARBARA GELLAI

AMERICAN MATHEMATICAL SOCIETY
Providence, Rhode Island

Cover photograph courtesy of the late Ida Rhodes: Cornelius Lanczos, visiting researcher at Boeing Aircraft Company, in 1944.

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To the memory of my parents
with love and gratitude

Contents

Preface

Whether in the world of truth [science] or in the world of beauty [art], the human mind, on its way towards the ultimate cognition, endeavors to understand the intrinsic nature of things; not to understand things as they are but as they must be—this is the intrinsic necessity.

Lanczos: "Science as a Kind of Art", 1973

It is widely thought that science and art have hardly anything in common, that they in fact exclude each other. We mention here several of their different characteristics on the basis of Cornelius Lanczos's paper "Science as a Kind of Art".

Science is concerned with *facts* established by careful experiments. The artistic fantasy can create a world that is not subject to the unchangeable laws of the physical universe. The method of science is logic. Starting from a few universal statements, the scientist can obtain new results by logical reasoning. Art need not be logical. In art the logic of pure reasoning is replaced by an *emotional* and *intuitive* way of understanding

"Whatever the laws of the universe may be, they will not be changed by personal sympathy or antipathy; the scientist makes a recording of the physical events only, while his personality remains in the background. In the world of art, on the contrary, *human* emotions and human reactions to certain situations in life are of interest" [**1**, p. 4–103].

The sharp distinction, however, that science is factual and art is visionary cannot be maintained in every case. We would hardly make a big mistake by claiming that almost every great discovery in science could be considered as the achievement of an ingenious and inspired mind rather than one of mere factual inference.

We are all, scientists or artists, each one in his own way, seekers of the truth. The one who takes this road, however, should not forget that the result is not guaranteed. The history of science teaches us that each time we proudly think that we have it all figured out, we will be surprised at having even more difficult problems than we had before. This is the time to reflect back and marvel at the journey we have taken so far. While going further, we experience, as Einstein did, that "Lessing's comforting words stay with us: The aspiration to truth is more precious than its assured possession"[1] [**2**].

We invite the reader to discover, in learning about the life and science of Cornelius Lanczos, the intrinsic nature of things, to understand things not as they *are* but as they *must* be. We believe you will enjoy the journey.

Cornelius Lanczos was a great admirer of Greek philosophy and cultural tradition. For him, dealing with science, probing the secrets of nature, was that "pathos philosophikon" (the passion for knowledge) with which Aristotle so beautifully describes the essence of the scientist. Having a very deep awareness of beauty in science, Lanczos regarded "science as a kind of art". For him a beautiful theory was in some sense truer than an unbeautiful theory. We will learn how his philosophical disposition motivated his research.

A posthumous appreciation summarized his achievement briefly: He was a great scientist and a great man. These are two great testimonials, and the second one is no less important than the first. In this book we follow this exceptional career from his homeland, Hungary, through Germany and the United States, then back to Europe into

[1] Lessing, Gotthold Ephraim (1729–1781), German dramatist and critic, was a vigorous and prolific writer on literary, philosophical, and theological subjects and the outstanding figure of the German Enlightenment. Academic American Encyclopedia, Grolier Incorporated, Danbury, Connecticut, Volume 12, 1991, pp. 298–299.

Ireland. We will analyze how the social and historical circumstances of these countries affected his career. In addition to his life story, his mathematical methods and the novelty of his ideas in physics will be described. We attempt to use simple terminology as far as possible or to explain scientific notions briefly. The goal is not to give the mathematical details of his theorems or to prove their exactness. We could not do it better than he did. Rather, it is to make them understandable not only for professionals but for educated laymen as well.

Choosing the subjects to discuss was not easy. Lanczos's publications cover two huge fields: mathematics and physics. In both fields his extremely flexible mind touched important and interesting topics, producing such unique algorithms and ideas that one gets the overwhelming feeling that everything was important. To write a book of moderate size, however, one must make hard choices.

As for mathematics, we received help from the man himself: In the last interview of his career, he named the Tau method, the matrix eigenvalue approximation method (now known as the Lanczos Method), and the linear systems in self-adjoint form as his three most important contributions to mathematics.

In physics, we investigated how his results contributed to other subjects, determined the course of his research, and influenced his career. We came up with the following: The geometric model Lanczos applied in his early paper "Surface Distribution of Matter in Einstein's Theory of Gravitation" later proved to be very important in the dynamics of bubbles in inflationary cosmology.

His contribution to quantum mechanics was the first continuum representation of quantum mechanics. His publication on the topic preceded Schrödinger's epoch-making paper by two weeks. This assigned him a special position in the history of science.

The results Lanczos achieved in the field of "Matter Waves and Electricity" motivated Schrödinger to invite him to the Dublin Institute for Advanced Studies and earned him the senior professorship in theoretical physics, the post he filled until the end of his life.

His investigation of undulatory Riemannian spaces determined the course Lanczos followed in his quest for a unified field theory during the Dublin period. His research in the field culminated in his very last paper in physics on the topic of gravitation and Riemannian space.

To readers interested in the mathematical details, we recommend Lanczos's papers, a complete list of which can be found at the end of the book.

Acknowledgements

Thanks are due to Jerry L. Whitten, Richard R. Patty, and William R. Davis for making the author's participation possible in the Lanczos Centenary Project of the College of the Physical and Mathematical Sciences at the University of North Carolina, Raleigh, NC, in the 1990s. The cooperation of Christopher R. Gould and of Wesley O. Doggett for bringing the publication of Lanczos's Collected Papers to a conclusion is appreciated.

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Mrs. Eleanor Boyk's permission to quote from Lanczos's letters is appreciated.

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track down the location of Lanczos's FBI file were sent to the legal successor of the NBS-INA. They have not succeeded up to this time.

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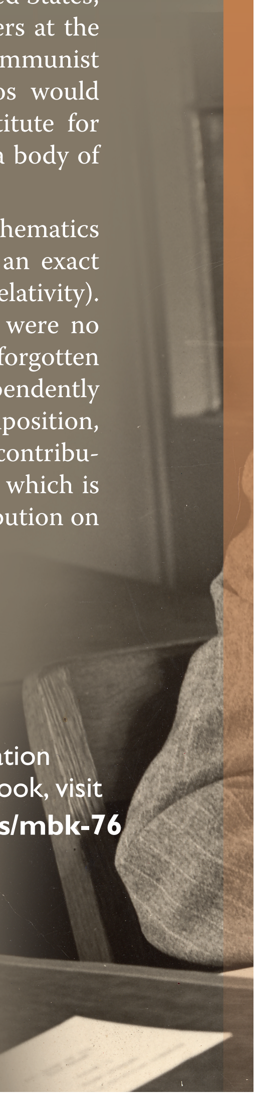
Index

This book recounts the extraordinary personal journey and scientific story of Hungarian-born mathematician and physicist Cornelius Lanczos. His life and his mathematical accomplishments are inextricably linked, reflecting the social upheavals and historical events that shaped his odyssey in 20th-century Hungary, Germany, the United States, and Ireland.

In his life Lanczos demonstrated a remarkable ability to be at the right place, or work with the right person, at the right time. At the start of his scientific career in Germany he worked as Einstein's assistant for one year and stayed in touch with him for years thereafter. Reacting to anti-Semitism in Germany in the 1930s, he moved to the United States, where he would work on some of the earliest digital computers at the National Bureau of Standards. After facing suspicion of Communist sympathies during the McCarthy era in the 1950s, Lanczos would relocate once again, joining Schrödinger at the Dublin Institute for Advanced Studies. Gellai's biography analyzes a rich life and a body of work that reaches across many scientific disciplines.

Lanczos made important contributions to several areas of mathematics and mathematical physics. His first major contribution was an exact solution of the Einstein field equations for gravity (in general relativity). He worked out the Fast Fourier Transform, but since there were no machines on which to run it, this accomplishment would be forgotten for 25 years. Once he had access to computers, Lanczos independently rediscovered what is now known as the singular value decomposition, a fundamental tool in numerical methods. Other significant contributions included an important discovery about the Weyl tensor, which is now known as the Lanczos potential, and an important contribution on algorithms for finding eigenvalues of large matrices.



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