

## Preface

This tale of the Italian mathematicians who provided Albert Einstein with the crucial mathematical architecture for general relativity might never have come about had it not been for a piece of mail that surfaced more than forty years ago in the correspondence of a very different mathematician, the Hungarian-born polymath Theodore von Kármán. He spent many years on the faculty of the California Institute of Technology, and early in my career as Caltech's first archivist, while rummaging through a collection of his letters, I came across one that he had received in 1922 from Tullio Levi-Civita, a mathematics professor in Rome. The name was unfamiliar to me, but even before reading the letter, I was struck by the handwriting. Unlike many scientists whose scrawls I had alternately puzzled over and despaired of, Levi-Civita had mastered the art of penmanship. His script was distinguished by bold, slightly exaggerated letters, with every I dotted and T crossed. His prose marched in straight, confident lines across the page, all correctly punctuated. What he had to say was at least as interesting as his handwriting: In the bitter aftermath of World War I, the victorious Allied nations, including Italy, had actively discouraged their scientists from attending meetings with their counterparts in the defeated nations of Germany and Austria-Hungary. Von Kármán, then still teaching in Germany, had evidently written to Levi-Civita to ask for his help in lifting the embargo. In his response, Levi-Civita had offered his enthusiastic support, now that “the brutal parenthesis of the war” had ended, for an international conference von Kármán proposed holding in Innsbruck, Austria. “Almost” all of his Italian colleagues would attend, he assured him, “without deplorable lingering of a bellicose mentality” still sometimes displayed by their peers.

Intrigued by the tone of the letter, I decided to investigate further. I quickly discovered that Levi-Civita had been perhaps the most brilliant and versatile member of a circle of influential Italian mathematicians—a number, like him, from Jewish backgrounds—that had flourished in the decades after the unification of Italy in 1870, only to be undone by the collapse of the nation's democratic institutions following the rise of Mussolini and fascism in the years leading up to World War II. He himself had died in 1941, stripped of his academic posts and prerogatives under the state's anti-Semitic laws and ostracized by colleagues who only a few years earlier had hailed him as their field's shining light.

My language skills did not extend to Hungarian and my German wasn't much better, but I could read and, after a fashion, speak Italian. Moreover, I would be accompanying my physicist husband, David, on his research trip to Rome in the near future. Putting aside for the moment any further inquiries into von Kármán, I found myself not long afterward standing in front of Via Sardegna 50, Levi-Civita's last known address in Rome. There I encountered a kindly janitor who told me that Levi-Civita's widow, Libera, had recently moved to another part of the city. While I stood in the empty apartment, he called her and handed me the phone. In my halting Italian, I introduced myself and explained my interest, and she invited me to visit her, which I did about a week later.

When I met Libera for the first time that summer, I knew painfully little about her and not that much more about her distinguished husband. Considering that she knew absolutely nothing about me, her subsequent generosity was astonishing. We talked for a while and then she directed me to an armoire located in an alcove adjacent to her living room, and said, "His letters are here." I already knew Levi-Civita to be a tireless correspondent, whose letters, written between 1896 and 1941, had been promised to Italy's Lincei Academy of Sciences, but I had not expected to find them tucked away in a corner of her home, numbering in the thousands.

A few weeks later we met again, and this time she introduced me to her son in law, Pier Vittorio Ceccherini, a professor of mathematics in Rome who had been a student of Beniamino Segre, now the president of the Lincei. The three of us came to an understanding that I could examine some of the letters while I was in Rome and that the Lincei would mail the complete collection to me in Pasadena, California, the following summer. They arrived still tucked in their envelopes, bundled together by year, each packet neatly tied with string. Over the next several months, I pored over their contents, consulted other sources, and began assembling a picture of Levi-Civita's life, his research, and the intellectual milieu in which he lived and worked. I discovered that he and his mathematical peers had assumed the primary role in disseminating relativity theory throughout Italy's scientific community, and that Levi-Civita himself had carried on a lively correspondence with Einstein in the years immediately before and after World War I. I presented the early fruits of this research in an invited talk at the Lincei Academy in 1973 and over the next decade published a handful of additional articles about Italy's nineteenth-century renaissance in mathematics.

Years later, having completed a book about the history of Caltech, I returned to the themes of those earlier pieces and expanded them into a book *The Volterra Chronicles*, which was published in 2007. It was sometime afterward that Sergei Gelfand, my shrewd and knowledgeable publisher at the American Mathematical Society, said to me, "What about Ricci?" Well, what about Ricci? He was certainly not one of the flashier figures of that era. Thinking back to Levi-Civita's letters, I vaguely recalled that Gregorio Ricci had been his professor and later his colleague at the University of Padua.

Their subsequent relationship had been close enough, I soon discovered, for Levi-Civita to have delivered an eloquent and emotional tribute to him at the Lincei in 1926, a year after his death. I located a copy of that talk (which is translated into English for the first time here in its entirety), read its account of the indispensable role Ricci's absolute differential calculus had played in the formulation of general relativity, and embarked on a journey that has brought me here.

The premise of this book is simply this: that the part Ricci and Levi-Civita played in contributing to Einstein's theory is a story that deserves to be told and told to a wider audience than it has reached to date. Recognizing Gregorio Ricci for his role in this saga—a mathematician who spent his whole adult life engaging in what the mathematical physicist Freeman Dyson has called “unfashionable science,” but who also had the extraordinary good fortune to encounter Tullio Levi-Civita as an effervescent student at Padua and form an enduring friendship with him—has been the driving force behind this narrative. Einstein, of course, features in this drama too—not the central figure but still a major player whose sudden, somewhat disheveled, appearance in the third act throws into sharp relief the role of its principals in setting the stage for one of the great, transformative discoveries of twentieth-century science.

**Acknowledgments.** This book owes much to Pier Vittorio Ceccherini and Susanna Silberstein Ceccherini, who first opened their home to me more than forty years ago and permitted me unfettered access to Levi-Civita's correspondence and private documents and other manuscript material in their possession. Tullio Ceccherini-Silberstein, their son, also a mathematician, shared family photographs with me and read the chapters as did my colleagues Tilman Sauer and Michele Vallisneri, who rescued me from time to time with their mini-tutorials on relativity and tensors. Donald Babbitt, who has been my mentor in all things mathematical, has been a loyal friend and staunch supporter for the past decade.

The publisher of the American Mathematical Society, Sergei Gelfand, made me an offer I couldn't refuse in suggesting that Ricci deserved to be brought out of the shadows. He challenged me to answer the question: “Who was he?” In 2004, Fabio Toscano published an Italian-language book about Ricci and Levi-Civita, which I found helpful.

While the considerable archival research undertaken in the preparation of this book is amply reflected in the footnotes, the kindness and generosity of the many archivists and librarians who facilitated my work deserve a special thank you. In particular, I would like to thank Orith Or Burla, Chaya Becker, and Roni Grosz, all of the Albert Einstein Archives at The Hebrew University of Jerusalem, for their help and permission to quote from The Collected Papers of Albert Einstein. In the early stages of writing this book, I was a visiting associate at the Einstein Papers Project at Caltech, courtesy

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In Rome, Francesca Rosa provided many hours of much-needed research help in the Archivio Centrale dello Stato; the Archivio di Stato; the Archivio Storico and the Physics Department of the University 'La Sapienza'; the Archivio Storico del Senato della Repubblica; and the Accademia Nazionale dei Lincei. I am grateful for the help she received from Mariapina Di Simone, Carla Onesti, Marco Guardo, Susanna Panetta, and Andrea Dibitonto. In Pisa, my thanks to Diana Toccafondi, Giovanna Tanti, Daniela Staccioli, Damiano Cecchi, Sandro Di Majo, Maddalena Taglioli, Anita D'Orazio, Mauro Bellandi, and Alessandro Masi at the Archivio di Stato, the Scuola Normale, and the Università di Pisa, who answered countless questions, supplied copies of documents, and in some cases photographs. I thank all of them for their help and permission to quote from materials in their repositories.

In Lugo di Romagna, Luisa Bedeschi and Ivana Pagani provided friendship, enthusiasm, unlimited scans, and many helpful suggestions as Carlotta Scaramuzzi, who translated many of the documents, and I delved into the Ricci papers. Enrico Sangiorgi, the great-grandson of Gregorio Ricci, accompanied by his aunt, Anna De Rossi, organized a visit to Ricci's country house in nearby Sant'Agata sul Santerno, including a reception in the town's library offered by Armanda Capucci, the librarian and Enea Emiliani. The high point of the day for me was a tour of the house itself, which gave me a real sense of Ricci's way of life there.

In Padua, I had a lively correspondence with Mariarosa Davi, a teacher at the prestigious Liceo Ginnasio Tito Livio, who went beyond the call of duty to track down and send me Tullio Levi-Civita's pre-university academic records. Across the Alps, Bärbel Mund in Göttingen provided help in locating Ricci correspondence in the Felix Klein Nachlass, and Heike Hartmann offered assistance in selecting pictures in the ETH's photographic archive.

Closer to home, my appreciation goes to the document delivery staff at Caltech's Sherman Fairchild Library, who never failed to find the pamphlets, articles, and books I needed. A big thanks also to Loma Karklins and Elisa Piccio in the Caltech Archives who gave their time and help to my book-writing project.

Translations from one language to another can be unusually challenging at times. I enlisted the help of my husband, David, and our daughter, Marcia Goodstein, in translating several difficult documents from the Italian; Donald Babbitt did the same for French material. James T. Smith provided a valuable preliminary translation of Levi-Civita's memoir about Ricci's life and work.

Various friends have read the chapters and provided thoughtful and constructive suggestions.

I owe a special debt of gratitude to Heidi Aspaturian, my long-time editor and colleague at Caltech, who through many detailed and discerning readings of the chapters helped turn the manuscript into a compelling story. As the saying goes, behind every writer is a better editor and in my case, certainly, that statement has never been truer or more appreciated.

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