Feature article

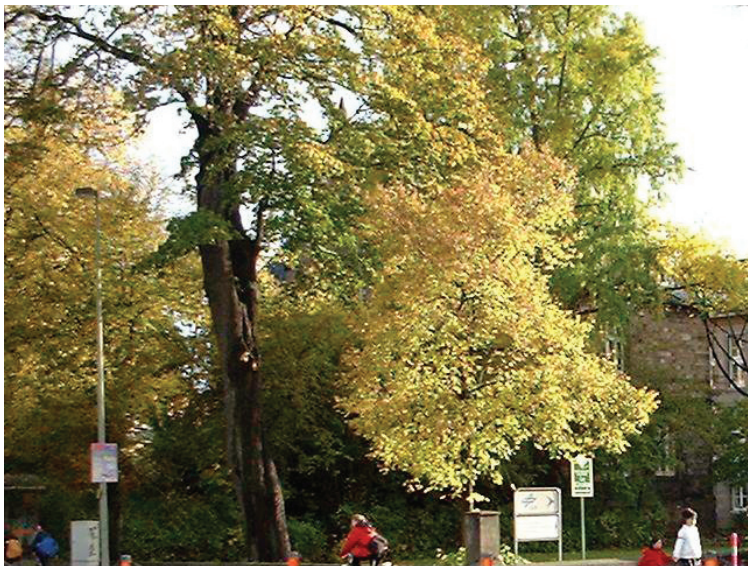
CMI–Göttingen Library Project

The Felix Klein Protocols Digitized by Eugene Chislenko

Two plain shelves in Göttingen, in the entrance room of the mathematics library, hold one of the best-kept secrets in the history of mathematics. In this locked *Giftschrank*, or poison cabinet, stand several hundred volumes, largely handwritten and mostly unique, that form an extensive record of one of the world's most important mathematical centers, the home of Gauss, Riemann, Dirichlet, Klein, Hilbert, Minkowski, Courant, Weyl, and other leading mathematicians and physicists of the 19th and early 20th centuries. A recent *Report on the Göttingen Mathematical Institute Archive* cites "a range of material unrivalled in quantity and quality: No single archive is even remotely comparable," not only because Göttingen was "the leading place for mathematics in the world," but also because "no other community has left such a detailed record of its activity — usually we are lucky to have lecture lists, with no indication of the contents." The collection runs from early handwritten lectures by Riemann and Clebsch through almost 100 volumes by Hilbert to volumes of Minkowski on number theory and Max Born on quantum mechanics. But the largest and richest of its centerpieces is the Seminar-Protokolle of Felix Klein: a detailed handwritten record, spanning over 8,000 pages in 29 volumes, of 40 years of seminar lectures by him, his colleagues and students, and distinguished visitors.

The record begins in 1872, when the 23-year-old Klein began his new professorship at Erlangen with the announcement of his revolutionary Erlangen program, unifying the various geometries of the time by classifying them by their corresponding groups of transformations. He had recently proved that non-Euclidean geometry is consistent if and only if Euclidean geometry is, and he would go on to do ground breaking work in many other areas, becoming, along with Hilbert and Poincaré, the last of the mathematicians who could claim to have a grasp of the entire field. Klein then moved to Münich, Leipzig and finally Göttingen. His energy and administrative talent made him the central figure in Germany's leading mathematics department at Göttingen, the nation's leading mathematics journal *Mathematische Annalen*, its first national association of mathematicians, and a program of reforms in higher education that became known as the Klein reforms. His influence on all aspects of mathematical life was unmistakable, even in his wife's wedding dress, patterned with arabesques from Kummer surfaces.

Klein's impact was especially strong in the United States. By 1875, in the first century after the Revolution, the growing network of American universities had only managed to award six doctoral degrees in mathematics, an average of less than one per decade. As programs finally began to expand and to look to Europe for inspiration, Klein took up the challenge, making repeated trips to the United States to present the latest in modern mathematics to his eager listeners. His series of lectures in Evanston, Illinois, held in conjunction with the World's Fair in Chicago and now known as the Evanston Colloquium, had a legendary influence, as did his tours of the universities on the East Coast. Klein himself soon became convinced of the potential of American mathematics, and worked to organize funding for the brightest American students to study in Göttingen. He was soon supporting a steady stream of enthusiastic American visitors. Harry Walter Tyler from MIT wrote, "I know of no one who can approach him as a lecturer…. He's certainly acute, fertile in resource, not only understands other people, but makes them



Mathematisches Institut Georg-August-Universität, Göttingen.

understand him, and seems to have a very broad firm grasp of the philosophical relations and bearings of different subjects, as well as great versatility and acquaintance with literature."

Tyler was one of many Americans to be marked by the breadth and power of Klein's teaching, and to leave their own mark, first in his *Protokolle* and then in the world at large: six of the American Mathematical Society's early presidents and two of the University of Chicago's first three mathematics professors were students of Klein.

The *Protokolle* cover every aspect of his astonishingly wide-ranging activity. The first volume alone includes presentations not only on Lie groups, icosahedra, Riemann, and Abel's Theorem, but also on heat distribution, crystals, comets, and the theory of the Northern Lights. From an early emphasis on geometry, group theory, and function theory, the other volumes expand into number theory, probability theory, mechanics, astronomy, geodesy, hydrodynamics, electricity, elasticity theory, and, in Klein's last years before his retirement in 1912, the psychology and teaching of mathematics. The meetings were small and on a high level. Participants included the young Pauli and Zermelo, Planck and Hurwitz, Prandl and Bernstein. Many of the later seminars were organized jointly with Hilbert and Minkowski, whom Klein had attracted to Göttingen and who shared his commitment to a close tie between mathematics and physics. Presentations made in the seminar were painstakingly recorded in the Seminar-Protokolle books, just as Göttingen mathematics lectures were recorded in other notebooks and placed in the library for students' reference. These notebooks have continued to astonish those who see them, and they remain the most complete record of a great era of mathematical creativity.

To make these volumes more widely available, CMI and Professor Yuri Tschinkel have organized a digitization initiative, using the latest in scanning technology to digitize the complete *Protokolle* in November of 2006. They are now being published for the first time, in a digital edition available online at www.claymath.org/library/historical. The full resolution scans are available for study by scholars at CMI and at the Göttingen Mathematical Institut at www.librarieswithoutwalls.org/klein.html.

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