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Women Mathematicians at Berkeley—The Early Years

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The author's book, *Mathematics at Berkeley—A History,* an account of the history of the UCB Mathematics Department, will be published later this year by AKPeters Ltd. This article is composed largely of extracts from this book together with contextual material. The author is indebted to Alice Silverberg, who suggested the possibility of such an article and that it might appear in this *Newsletter.* Important sources for the book and this article include the University of California In Memoriam series of the UC History Digital Archives, Constance Reid's biography, *Julia—A Life in Mathematics,* and the biographical materials and essays from the 2000 Lehmer Conference at UCB. The author is grateful to AKPeters for permitting publication of this extracted material in this format. The author also thanks the University Archives of the Bancroft Library, The UC Berkeley Mathematics and Statistics Departments, George Bergman and the Lehmer family for permission to reproduce the photographs used here.

This is the story of six women mathematicians, all born in the period from 1885 to 1920, who played important roles in the UC Berkeley Mathematics Department beginning in the early decades of the 20th century. All were pioneers in different ways. These mathematicians were Pauline Sperry, Sophia Levy McDonald, Emma Trotskaya Lehmer, Evelyn Fix, Elizabeth Scott, and Julia Robinson. All but Emma Lehmer held tenured positions at Berkeley; Emma was married to Derrick H. Lehmer, a long time faculty member at Berkeley. She published actively both by herself and jointly with her husband, taught occasionally in the department, and was a strong mathematical presence in Berkeley and nationally, contributing to the department's stature. In order to provide context for the stories and the events in the lives of these women mathematicians, some brief comments on the history of the department are needed.

The University of California was founded in 1868 and opened for instruction in Fall 1869. The mathematics faculty consisted of two people, both of whom were graduates of the United States Military Academy (West Point) and who imported the West Point mathematics curriculum. This changed in 1882 when the Regents replaced them with Washington Irving Stringham, who had studied under Benjamin Peirce as an undergraduate at Harvard, received his Ph.D. under J. J. Sylvester at Johns Hopkins, and had spent two postdoctoral years studying under Felix Klein in Germany. His appointment represented a break with the initial leadership of the department. In 1890, Stringham was joined by Mellin Haskell, another Harvard graduate who had received his doctorate under Klein at Göttingen. Subsequent additions to the faculty in this era included Derrick Norman Lehmer, a doctoral student of E.H. Moore at the University of Chicago, who came in 1900, and John Hector McDonald, a doctoral student of Oskar Bolza, also at the University of Chicago, who came in 1902. Stringham, and then Haskell after Stringham's death in 1909, ran the department from 1882 until Haskell's retirement in 1933. Initial appointments to tenure were extremely rare as the university's long standing policy was to grow its own. Almost all appointments were thus at the beginning tenure track level, which until more recently was Instructor. Advancement up the ladder was at many times painfully slow in the early years.

The first mathematics doctoral degree at Berkeley was granted in 1901, but there was a hiatus until 1909, after which doctoral production averaged somewhat under two per year until the mid-thirties. Even though the mathematics faculty had grown to about 12 in 1910 and to about 18 in the mid-thirties, Haskell, Lehmer, and MacDonald were essentially the only ones to supervise dissertations. In the thirteen year period 1909 to 1921, Berkeley produced 18 doctorates in mathematics, 4 of whom were women. By comparison, all US universities during the same period produced 280 mathematics Ph.D.'s, 39 of whom were women (according to the Mathematics Genealogy website [3]); Berkeley was not statistically different from the national pattern. During the following 20 year period through 1941, Berkeley produced 52 doctorates in mathematics including 5 women; the corresponding national numbers (again based on Mathematics Genealogy listings) were 1367 with 155 women. Again the Berkeley numbers are not statistically significantly different from the national pattern. These statistics reflect a stronger presence of women in mathematics graduate programs in the early decades of the 20th century, followed

by a steady decline nationally in the percentage of women doctorates until the late sixties, when the numbers began to increase rapidly.

As Haskell's 1933 retirement neared, faculty in other science departments, as well as the Provost and the President of the University, realized that mathematics was a department that had suffered from inbreeding, had focused too exclusively on its teaching mission and had fallen far behind other departments on campus in developing excellence in research. The end result was that the campus took the exceptional step of recruiting the distinguished and established scholar Griffith Evans as Chair from the Rice Institute in Houston with a charge to remake the department. Starting in 1934, he served as Chair for 15 years and succeeded brilliantly in this task. He made many fine appointments, but for purposes of this narrative, two are of special significance. One was Jerzy Neyman, who was brought in to develop statistics, a field that had not been represented at Berkeley. The second was Alfred Tarski, who was recruited to the faculty in 1942; this appointment led to the development of a strong school of logic that has prospered at Berkeley. From the day Neyman arrived in 1938, his goal was the creation of an independent department of statistics. Evans supported Neyman in his quest for hiring faculty in statistics, but firmly resisted Neyman's efforts for an independent department. It was only in 1955 after Evans had stepped down that Neyman succeeded in his goal of a separate department.

The University was shaken to its core in 1949–50 by the Loyalty Oath Controversy in which the UC Regents tried to impose on all employees, but especially the faculty, a disclaimer oath in which all employees had to swear under oath that they were not members of the Communist Party. This resulted in a collision between the faculty and the Regents, and the Regents ended up dismissing in 1950 a small number of mostly tenured faculty who for a variety of principled reasons had declined to sign the oath. In a subsequent law suit, the disclaimer oath was ruled illegal by the State Supreme Court in 1952, and the Regents were ordered to reinstate the dismissed faculty. Berkeley mathematics faculty were over-represented among the dismissed faculty, and while the Oath Controversy damaged the department, it did in time recover.

With this as background, let us turn to the lives of these women mathematicians. The first one hired at Berkeley (or California as it was then called) was Pauline Sperry in 1917. Sperry was born in Massachusetts on March 5, 1885 and graduated from Smith College in 1906. She stayed on at Smith for graduate work and then taught mathematics at Smith from 1908 to 1912 before deciding to pursue further graduate study in mathematics at the University of Chicago. There she worked under Professor Ernest Wilczynski, formerly

Call for Nominations: The 2008 Noether Lecture

AWM established the Emmy Noether Lectures to honor women who have made fundamental and sustained contributions to the mathematical sciences. This one-hour expository lecture is presented at the Joint Mathematics Meetings each January. Emmy Noether was one of the great mathematicians of her time, someone who worked and struggled for what she loved and believed in. Her life and work remain a tremendous inspiration.

The mathematicians who have given the Noether lectures in the past are: Jessie MacWilliams, Olga Taussky Todd, Julia Robinson, Cathleen Morawetz, Mary Ellen Rudin, Jane Cronin Scanlon, Yvonne Choquet-Bruhat, Joan Birman, Karen Uhlenbeck, Mary Wheeler, Bhama Srinivasan, Alexandra Bellow, Nancy Kopell, Linda Keen, Lesley Sibner, Ol'ga Ladyzhenskaya, Judith Sally, Olga Oleinik, Linda Rothschild, Dusa McDuff, Krystyna Kuperberg, Margaret Wright, Sun-Yung Alice Chang, Lenore Blum, Jean Taylor, Svetlana Katok, Lai-Sang Young, and Ingrid Daubechies.

The letter of nomination should include a one-page outline of the nominee's contribution to mathematics, giving four of her most important papers and other relevant information. *Five* copies of nominations should be sent by **October 15, 2006** to: The Noether Lecture Committee, Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030. If you have questions, phone 703-934-0163 or e-mail awm@awm-math.org. Nominations via e-mail or fax will not be accepted.

a Berkeley faculty member, in projective differential geometry. Her dissertation was entitled *Properties of a Certain Projectively Defined Two Parameter Family of Curves on a General Surface,* and a paper based on it was subsequently published in the *American Journal of Mathematics.* She returned to Smith for a year as Assistant Professor before coming to Berkeley as an Instructor in 1917. She was promoted to Assistant Professor in 1923 and to Associate Professor in 1931. Although she published infrequently, she did supervise five doctoral dissertations during the 1930s and 40s. One publication of note was her 1931 "Bibliography of Projective Differential Geometry." She was a devoted teacher and prepared two textbooks for freshman mathematics. In 1945 she was selected as Chair of the Northern California Section of the Mathematical Association of America.

Pauline Sperry

Sperry was raised as a Quaker and throughout her life practiced her ethical and moral beliefs. In 1950 she firmly believed that the Loyalty Oath encroached on political freedom, and consequently she declined to sign it. She was fired from the University, but as a result of the litigation, she was reinstated just prior to her retirement in 1952. After retirement she moved to Carmel and devoted herself to her causes and to charitable projects. On the occasion of her 80th

birthday, she published an article in the *Smith Alumnae Quarterly,* "Formula for Happiness at Eighty," [5] which begins:

> Everybody knows that unless you personally do something about it, you will feel needed less and less as you grow older. At eighty, I feel needed more and more, and I am eager to tell the secret. Oscar Wilde once said, "Men who are trying to do something for the world are always insufferable, when the world has done something for them, they are charming." The world has done so much for me that I do not mind being insufferable, and I let the charm fall where it may.... I have always burned for causes....

One of her causes was an orphanage in Haiti which she writes about in the article. This article provides insight into the generosity and spirit of this remarkable woman who had not been treated at all well by the University. She died shortly after writing this in 1967.

The second woman mathematician to join the faculty was Sophia Levy, who was appointed in 1921. Her doctoral degree and major research work lay in celestial mechanics which by this point in time had moved from being seen as part of mathematics to being seen as part of astronomy. Her mentor, Armin Leuschner, had originally been in the mathematics department in the 1890s, but he had moved into a newly created Astronomy Department that he chaired for 31 years. He was a distinguished scholar, an early member of the National Academy, and a major figure on campus.

Sophia Hazel Levy was born in Alameda, California on December 12, 1888 of parents who were also native Californians. She attended UC and graduated with a major in astronomy in 1910. Continuing with graduate studies in astronomy, she completed a dissertation under Armin Leuschner in 1920 on the motion of comets and minor planets. During her time as graduate student, she also served for four years as assistant to the Dean of the Graduate Division and for two years as Secretary of the Commission on Credentials of the State Board of Education. After appointment as Instructor in 1921, she was advanced to Assistant Professor in 1924, Associate Professor in 1940 and Professor in 1949.

She contributed scholarly papers to the literature concerning the motions of comets and minor planets. The memorial article on her life states: "Since her work in astronomy required handling of extensive numerical data,

Sophia Levy McDonald

she quite naturally directed herself to the field of numerical analysis, including such subjects as interpolation methods, mechanical quadratures, the numerical solution of algebraic and transcendental equations, Fourier analysis and periodogram analysis." During World War II she taught courses in the mathematics of antiaircraft gunnery to armed services personnel at UC Berkeley and later published a text on the subject with UC Press. She was also deeply engaged in the preparation of secondary school mathematics teachers, was the departmental advisor for prospective teachers and served on a number of regional and state-wide committees on mathematics education. With A. L. McCarty of San Francisco City College, she founded in 1939 the Northern California Section of the MAA, serving first as Secretary of the section, next as Vice-President, and then President and Sectional Governor.

At some point in her career, at a time lost in the mists of history, she formed a close personal relationship with her departmental colleague John Hector McDonald, who was 13 years her senior. They had hoped to marry, but marriage was precluded by the university's strict nepotism rules which did not allow close relatives to be employed in the same department. One or the other would have had to resign. In any case they waited until John reached mandatory

retirement age and in 1945 they married. She was subsequently known as Sophia Levy McDonald. John died in 1953 and his In Memoriam article states: "The colleagues who were privileged to have insight into his character, his intellectual power, and his artistic sensitiveness are grateful to Mrs. McDonald for the comfort and happiness which her devotion brought to his later years." [1]

Sophia retired from active duty in the department in 1954. At the time the department had an assistant professor on the faculty who was well qualified to take over McDonald's manifold responsibilities with respect to the training of teachers and was someone whom McDonald wished to succeed her. However the department declined to promote him to tenure because of the absence of a research record. It would be the better part of a decade before the department again focused efforts on the training of teachers.

McDonald's memorial article concludes appropriately as follows: "The daughter of pioneer parents in California, Sophia Levy McDonald viewed herself as somewhat of a pioneer for women in the field of study and research in the exact sciences. She contributed to the fame which the Astronomy Department enjoyed under the leadership of the late Professor Leuschner in the field of celestial mechanics, and she contributed significantly to the teaching of mathematics in the schools and colleges in California." [1]

The third woman mathematician in our story is Emma Trotskaya Lehmer. Emma Trotskaya was born November 6, 1906 in Samara, a city on the Volga River in Russia. Her family moved to Harbin, Manchuria in 1910 where her father Motvey Trotsky served as the Far Eastern representative of a large Russian firm. They were thus spared the trauma of World War I and Revolution, and they remained there as expatriates after the war. Emma had originally hoped to return to Russia for college, but the purges and famine in Russia made that impossible. She instead looked to the US, and she applied and was admitted to UC Berkeley in 1924 as a freshman. She developed an interest in mathematics and decided to major in it. During the summer of 1926, following her sophomore year, she got a job assisting Professor Derrick Norman Lehmer on a research project in number theory. While working on this project, she soon met and worked with Lehmer's son, Derrick Henry Lehmer, known as Dick, who was a math major one year ahead of her in college. Their friendship ripened into love, and Dick and Emma were married April 20, 1928 when he returned to Berkeley following

his year of graduate study at the University of Chicago. After a trip to Manchuria to meet her family, they returned, and both went off to Brown University. Dick had transferred there to finish his doctoral work, while Emma enrolled in the master's program at Brown.

After completing their degrees at Brown in 1930, the Lehmers moved around for ten years as Dick held various postdoctoral fellowships and then a faculty position at Lehigh University. Emma bore two children during this period in 1932 and 1934. The faculty position that Dick yearned for was of course a position at Berkeley; however, the university's nepotism regulations precluded that as long as his father was still on the faculty. His father retired in 1937, and in 1940 Dick Lehmer was appointed to a faculty position at Berkeley.

Emma began publishing mathematics papers shortly after receiving her master's degree, including three short notes in the *Bulletin of the American Mathematical Society*, the first one of which contained the results of her master's thesis. These were followed by a paper in the *Annals of Mathematics* in 1938, and then a *Bulletin* note jointly authored with her husband in 1941; all of this of course with small children in the house. The Lehmers spent the 1945–46 year at the Ballistic Missile Research Laboratory at Aberdeen where Dick was working with the ENIAC computer that was designed and used to compute ballistic trajectories. But on some weekends the Lehmers could use it as a numerical sieve. Emma recalls that "When they could arrange child care, they would stay at the lab all night long while the ENIAC processed one of their problems. They would return home at the break of dawn." [2]

After her 1941 paper Emma did not publish anything until 1951, when she resumed publishing mathematical papers, and a steady stream of publications in number theory followed. The last one appeared in 1993 when she was 87. In over 60 years of married life, which combined devoted family life as well as mathematics, the Lehmers co-authored 11 papers in number theory. But these form only a small part of Emma Lehmer's 56 total publications. Emma was also widely known for her fine translation of Pontrjagin's book *Topological Groups*.

Once Dick held a faculty appointment, the university's nepotism regulations did not permit her to hold a faculty position except for some short-term visiting positions to meet teaching needs. By the time these regulations were

Emma Trotskaya Lehmer, ca. 1928

rescinded in 1971 both were virtually at the age of mandatory retirement. In any case Emma never felt excluded from the mathematical community, and indeed was a vital part of it. She travelled with her husband to mathematical conferences around the world and had many research accomplishments [2]. The article in [2], which is based on interviews with her, says: "Emma Lehmer considers that she is quite fortunate in the way her career turned out. She would have liked to teach more (she taught some during World War II under special wartime exceptions to the university nepotism rules that usually prevented more than one member of a family from holding a faculty position). She considered that not having to teach freed her up to do research." In fact her publication record, judged just by the number of publications, exceeds that of any of the other five women we are discussing. Today Emma lives alone in the house in the Berkeley Hills that she shared with Dick, and will turn 100 not long after this account appears in print.

In 1938 Evans had successfully completed the recruitment of Jerzy Neyman from University College London to build up a school of statistics. As soon as he arrived, Neyman started to recruit students from many different disciplines to work with him in his Statistical Laboratory—the precursor of a separate department. A number of these students completed their doctoral degrees under Neyman and were subsequently hired into faculty positions at Berkeley.

Neyman justified this inbreeding on the grounds that virtually no other program was turning out well trained students in modern statistics. Among those recruited by Neyman to work with him who went on to faculty positions were two women, Evelyn Fix and Elizabeth Scott. Both were originally appointed in the Mathematics Department, but when statistics split off as a separate department in 1955, they joined the Statistics Department and spent the remainder of their careers in that department

Evelyn Fix was born January 27, 1904 in Duluth, Minnesota, and received her bachelor's degree in mathematics from the University of Minnesota in 1924. She went on to earn a BS in education in 1925. She then taught high school mathematics in Minnesota from 1925 to 1934, while also receiving an MA in Mathematics in 1933. In 1934, she moved to Seattle, Washington and worked as a high school mathematics teacher, secretary, and school librarian from 1934 to 1941. She had received a certificate degree in librarianship in 1936 from the University of Washington.

Prompted by a friendship with Evans developed during a summer school course she took from him in 1931 at Minnesota, she attended Summer Session at UC Berkeley in 1939 and again in 1940. The distinguished British statistician R. A. Fisher had also taught in this 1931 summer program at the University of Minnesota, and this may have prompted an interest in statistics. In any case, in 1941 she came to Berkeley to stay, signing on as Research Assistant under Neyman in the Statistical Laboratory. She continued her work during the war, supported on Neyman's grants and also teaching, first as an Associate and then as Lecturer in the Mathematics Department. After the War she completed her work for a doctoral degree under Neyman, and the degree was awarded in 1948. Her dissertation consisted of three parts, two of which were technical reports she had prepared while working in the Statistical Laboratory. The third part was entitled "Distributions Which Lead to Linear Regressions." She was appointed as a Lecturer for two years (1948–1950) before being appointed as Instructor in 1950 and then as Assistant Professor in 1951. She was promoted to Associate Professor in 1957 and to Professor in 1963. She died of a heart attack on December 30, 1965 shortly after returning home from a banquet for the Fifth Berkeley Symposium.

Her research interests ranged over a number of topics from early work on probability in her war work and her

F. N. David, Betty Scott, David Blackwell, and Evelyn Fox, ca. 1962

thesis, to work with J.L. Hodges on discriminant analysis, to work with Neyman which led to her computation of tables of the power of the chi-squared test and to problems of risks, and finally to joint work with F. N. David on statistical problems of biology and health. Her memorial article notes: "Aside from her own research, Miss Fix was very generous and very able in helping colleagues from the University and the community at large with statistical questions arising in their research. Many footnotes acknowledge this help." [1] During her career, she supervised the doctoral work of one student.

She helped with the organization of the periodic *Berkeley Symposia on Mathematical Statistics and Probability.* As her memorial article opines: "Miss Fix participated in the organization of the Statistical Laboratory and then of the Department of Statistics, essentially from the very start. It pleased her to see statistics come alive and she contributed a great deal to the spirit of the laboratory and department. In addition to other qualities she had an unusual gift for cooking and many of us will long remember her hospitality, at her apartment and, later, at her home with F. N. David in Kensington." [1]

Perhaps at this point some mention of F. N. (Florence Nightingale) David is appropriate as she was at times a presence in the Statistics Department at Berkeley, although

she was never a regular faculty member. She was born in England in 1909 and received her doctoral degree in 1938 at University College London, under Karl Pearson, the same year that Neyman left University College to come to Berkeley. David also subsequently served as a faculty member at University College London. In 1948 she began regular summer visits to Berkeley where she taught in summer session. She was subsequently recruited to the Riverside campus of University of California, and her memorial article states:

> After retiring from UC Riverside in 1977, Dr. David was named Professor, Emeritus and Research Associate at UC Berkeley where she continued to teach for another decade, and, at the same time, continued her long-term collaboration as a consultant with the United States Forestry Service. She was the author of nine books, two monographs, and over 100 papers in scientific journals. In August of 1992, she received the first Elizabeth L. Scott Award at the Joint Statistical Meetings in Boston. She was cited for "her efforts in opening the door to women in statistics; for contributions to the profession over many years; for contributions to education, science, and public service; for research contributions to combinatorics, statistical methods, applications, and understanding history; and her spirit as a lecturer and a role model." [1].

Elizabeth Leonard Scott was born on November 23, 1917 in Fort Sill, Oklahoma, where her father, an officer in the U.S. Army, was stationed. After graduating from high school in Oakland, California, she entered UC Berkeley in 1935 and majored in astronomy, graduating in 1939. Shortly after Neyman arrived at Berkeley in 1938, C. D. Shane, Director of the Lick Observatory, recommended to Scott that she learn statistics because he felt that applications of modern statistics to astronomy would be important but were not well developed. Scott then entered graduate school in astronomy, but split her time over the next ten years between the Astronomy Department, the Statistical Laboratory, and the Mathematics Department. She was a Research Assistant in the Statistical Laboratory for 1939–41 and a Teaching Assistant in Astronomy in 1941–42; she worked on Neyman's NDRC contract during the war. She was also a University Fellow in Astronomy for 1942–44 and then a

Betty Scott in the 60s

Teaching Assistant in Mathematics for 1944–46. After the war she worked as an Associate in Astronomy, as Research Assistant in the Statistical Laboratory, and then Lecturer in Mathematics.

During the war she worked on statistical problems concerning the effectiveness of bombing, and then began work on statistical problems in astronomy and bi-variate distributions. Her interests began in astronomy, but shifted more and more to statistics. After discussion with her mentors, she decided to submit a dissertation in astronomy, in which an astronomical problem was solved by statistical methods. Her dissertation, formally under the direction of Robert Trumpler in astronomy, but also effectively under Neyman as well, consisted of two parts (I) Contribution to the Problem of Selective Identification of Spectroscopic Binaries, and (II) Note on Consistent Estimates of the Linear Relation Between Two Variables. The degree was granted in 1949. She was appointed as Instructor in Mathematics on January 1, 1950, and was then promoted to Assistant Professor 18 months later. Advancement to tenure came in 1957 and to Professor in 1962. She served as Chair of Statistics from 1968 to 1973, and her memorial article says that she will be remembered by her deans as a feisty chair of her department and a champion of its students. (The two deans she served under were Walter Knight and the

author.) She supervised the dissertation of nine doctoral students during her career.

Throughout her career Scott contributed both to astronomy and to statistics. There is an observational feature concerning the formula used to estimate the distance to a galactic cluster known as the Scott effect. She began a life long collaboration with Neyman that included statistical problems concerning the distribution of galaxies, weather modification (cloud seeding), and carcinogenesis. In other work, singly authored, she explored ozone depletion and its possible effects. She also undertook statistical studies of career patterns of men and women in academia—work that resulted in several, influential reports. One such study undertaken with Elizabeth Colson collected and analyzed data on gender disparities and was reprinted by Congress. Another study on salary inequality was done for the Carnegie Commission and was used by institutions to make salary corrections.

She was an effective mentor and role model for many young women in science, and as noted above an award named in her honor was created. She was refreshingly and vigorously outspoken in many venues about discrimination and inequality. Finally, she held a number of important positions in professional societies—President of the Institute of Mathematical Statistics, Vice President of the International Statistical Institute, and Vice President of the Bernoulli Society—and was elected as an Honorary Fellow of the Royal Statistical Society (London). She retired from active duty July 1, 1988, and died unexpectedly a few months later.

NSF-AWM Travel Grants for Women

The objective of the NSF-AWM Travel Grants program is to enable women researchers in mathematics or in mathematics education to attend research conferences in their fields, thereby providing a valuable opportunity to advance their research activities and their visibility in the research community. By having more women attend such meetings, we also increase the size of the pool from which speakers at subsequent meetings may be drawn and thus address the persistent problem of the absence of women speakers at some research conferences. All awards will be determined on a competitive basis by a selection panel consisting of distinguished mathematicians appointed by the AWM.

Travel Grants. These grants provide full or partial support for travel and subsistence for a meeting or conference in the applicant's field of specialization. A maximum of $1000 for domestic travel and of $2000 for foreign travel will be applied. For foreign travel, U.S. air carriers must be used (exceptions only per federal grants regulations; prior AWM approval required).

Eligibility. These travel funds are provided by the Division of Mathematical Sciences (DMS) and the Division of Research, Evaluation and Communication (REC) of the NSF. The conference or the applicant's research must be in an area supported by DMS. Applicants must be women holding a doctorate (or equivalent experience) and with a work address in the USA (or home address, in case of unemployed mathematicians). Anyone who has been awarded an AWM-NSF travel grant in the past two years is ineligible. Anyone receiving a significant amount of external governmental funding (more than $2,000 yearly) for travel is ineligible. Partial travel support from the applicant's institution or from a non-governmental agency does not, however, make the applicant ineligible.

Applications. An applicant should send *five* copies of 1) the AWM Travel Grant Form, where conference name, conference dates and location (city/state/country), and amount of support requested should be provided, 2) a cover letter, 3) a description of her current research and of how the proposed travel would benefit her research program, 4) her curriculum vitae, 5) a budget for the proposed travel, and 6) a list of all current and pending travel funding (governmental and non-governmental) and the amounts available for your proposed trip to: Travel Grant Selection Committee, Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030. If you have questions, contact AWM by phone at 703-934-0163 or by e-mail at awm@awm-math.org. Applications via e-mail or fax will not be accepted. There are three award periods per year. The next two deadlines for receipt of applications are **October 1, 2006** and **February 1, 2007**.

Julia Robinson, ca. 1943

The final woman mathematician at Berkeley that we shall discuss is Julia Robinson. The news was electrifying—on April 27, 1976 it was announced that Julia Bowman Robinson had been elected to the National Academy of Sciences—the first woman to be elected to the Mathematics Section of the Academy. John Kelley, then departmental chair, decided that the department should immediately seize this opportunity to take what many regarded as the long overdue step of appointing Julia Robinson as a Professor of Mathematics.

Julia Bowman was born December 8, 1919 in St. Louis, Missouri, and shortly thereafter her family moved to Arizona and then to San Diego, California. She attended San Diego State College from 1936 to 1939 and then transferred to Berkeley for her senior year, where she received her bachelor's degree in mathematics in 1940. She continued on for graduate work at Berkeley, receiving a master's degree in 1941. Raphael Robinson, with whom she had taken a course in her first year at Berkeley, subsequently courted her successfully, and they were married on December 22, 1941, after which she was known as Julia Robinson. As a child she had suffered from rheumatic fever, an illness that had damaged her heart and kept her out of school for nearly two years. The illness had a life-long effect on her health, but heart surgery in 1961 followed by two other major surgeries in the 1960s allowed her to enjoy a more active life [4, p.68].

After receiving her master's degree she continued to study and work in the department, and for some time she worked in Neyman's Statistical Laboratory. Robinson became interested in mathematical logic under the influence first of her husband and then under the direction of Alfred Tarski. She completed her doctoral work under Tarski in 1948 with a dissertation entitled *Definability and Decision Problems in Arithmetic,* in which she proved that the notion of an integer can be defined arithmetically in terms of the rational numbers. This was a very significant result that had important consequences for other decision problems. After her doctoral work she became interested in Hilbert's 10th problem, which asks if there is a decision procedure for determining whether a diophantine equation with integer coefficients has a solution in integers. This was a topic that occupied her attention for the rest of her career. She published a number of significant contributions to the problem, first in 1952, then in 1961 (jointly with Martin Davis and Hillary Putnam), and in 1969, an improvement on the 1961 result. She formulated what was called by others the Robinson Hypothesis, and at that point she in fact was closer to a solution of the 10th problem (in the negative) than she imagined. It was in early 1970 that a 22-year-old Russian mathematician, Yuri Matijasevich, who, upon reading her 1969 paper, filled in the missing piece in a few weeks of work finally to resolve the 10th problem in the negative. Matijasevich and the mathematical community accorded Robinson substantial credit for her role in the solution. Davis also deserves a piece of the credit, as does Putnam. Robinson and Matijasevich subsequently collaborated on some further refinements to the solution.

Robinson's contributions to the resolution of this Hilbert problem brought her great recognition, with election to the NAS in 1976 being one of the major ones. She had never had a regular faculty position at Berkeley but had taught part time in the department on a number of occasions. Nepotism rules in place at the time would not have permitted her appointment, but Raphael took early retirement in 1971, so that nepotism was no longer an obstacle. (In any case, nepotism rules were rescinded in 1971 as a antiquated relic of the past.) As she states in her "autobiography": "In fairness to the University, I should explain that even after the heart operation, I would not have been able to carry a full time teaching load" [4, p.79]. After a conversation with the Dean, who

endorsed the proposal, Kelley approached Robinson shortly after her election to the Academy in the Spring of 1976 to ask if she was interested in an appointment as Professor in the department, where it was made clear that the appointment could be a part-time one with the percentage time of the appointment completely at her discretion. Her response was positive, and her choice was for a 25% appointment. It took several months to assemble the paperwork for the appointment and to gain approval for it through the various levels of review, and her appointment as Professor of Mathematics at 25% time was approved over the summer retroactive to July 1, 1976.

Many other honors for Robinson followed, including selection as Colloquium Lecturer of the American Mathematical Society in 1980 and then election as President of the Society in 1983—the first woman to serve as President of the Society. She was selected as Prize Fellow of the MacArthur Foundation in 1983. But in the summer of 1984 Robinson learned that she had leukemia. On July 30, 1985, she died of this ailment just weeks after her retirement from the university on July 1, 1985. All were saddened by this tragic event. She had very much hoped to return to her research after service as President of the AMS, but this was not to be. Her husband Raphael established the Julia Robinson Graduate Fellowships in Mathematics at Berkeley in her honor with an initial contribution, and after his death in 1995, the bulk of their estate came to the department to provide very generous funding for these fellowships.

What do we learn from the stories of these six women? They were of very different backgrounds and of personality. All were courageous and pioneers in their own ways, but at the very least, these stories show the presence and influence of women in the Berkeley mathematics community from a very early time. Pauline Sperry was certainly one of the first if not the first woman mathematician to be appointed to a tenure track position in a major research university in the US. Two of these women married early in life and only one, Emma Lehmer, had children. She was also the only one not to have held a regular faculty position. Julia Robinson wanted children, but after she became pregnant and lost the baby, her doctor advised her never to become pregnant again because of her heart problems [4, p. 43]. Another theme which comes through is the effect of the university's nepotism rules. One could have hoped that the university would have seen

Julia Robinson, 1976

how misguided this policy was earlier than 1971 when it was finally rescinded.

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