[I L A S] *IMAGE* [I L A S]

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Olga Taussky Todd: 1906–1995

The mathematical community suffered a profound loss when Olga Taussky Todd, one of the world's outstanding mathematicians, died in her sleep on Saturday, October 7, 1995, at home in Pasadena, California, where she was Professor Emeritus of Mathematics at the California Institute of Technology. She is survived by her husband, John (Jack) Todd, who is also Professor Emeritus of Mathematics there.

Grand plans had been made for 1996 when Olga would have been 90 on August 30 and when Jack will be 85 on May 16. Special issues were planned of *Numerische Mathematik* and *ETNA*. A biography of Olga (with the help of her husband of 57 years) was being prepared by one of us for presentation in 1996. We were sent advance copies of obituaries by Chandler Davis and by Richard Varga, which have since been published [*Association for Women in Mathematics Newsletter* 26 (January–February 1996), pp. 7–9; *SIAM News* 29 (January–February 1996), page 6]. The Caltech Mathematics Department will hold a one-day Symposium in Olga's honor on Saturday, April 13, 1996. It is hoped that these and other plans will materialize as tributes to Jack and to the memory of the "torchbearer for matrix theory" [*Amer. Math. Monthly* 95 (1988):801–812]. Her light radiated the research path of many who were influenced, directly or indirectly, by her teaching, her lectures at professional meetings, her articles—over 200 of them—especially her remarkable survey articles which coordinate different branches of mathematics, unify, trace, and simplify developments, and"which always add something new" [Hans Schneider, *Linear and Multilinear Algebra* 5 (1977), page 208]. Her famous papers, "A recurring theorem on determinants" [*Amer. Math. Monthly* 56 (1949): 672–676] and "Sums of squares" [*Amer. Math. Monthly* 77 (1970): 805–830] have become models for research and exposition. Also influential are the Research Problems she published, which stimulated and will continue to stimulate new research.

Olga Taussky was born in Olmütz in the Austro-Hungarian Empire on August 30, 1906. (After World War I, Olmütz became Olomouc in Czechoslovakia—now in the Czech Republic.) Her father was Julius David Taussky, an industrial chemist; her mother, Ida Pollach Taussky, ran the home with efficiency and affection. In 1909 the family moved to Vienna and, during World War I, to Linz, a small town in upper Austria, where her father was director of a vinegar factory. Her sister Ilona, three years older than Olga, became a consulting chemist, and her sister Hertha, three years younger than Olga, became a pharmacist and then a clinical chemist.

Olga's best subjects in elementary school were grammar and essay writing. Writing poetry was a life-time interest. "The music of mathematics" was discovered by her even before she entered the gymnasium, Körnerschule, in Linz. Her father's death in her senior year devastated the family both emotionally and financially. Increasing her tutoring load, and taking on a consulting contract for 1925 with the vinegar plant, Olga—the top student in her class—worried about preparing for the final examinations, the Matura. Although there was at first concern about funds for college, with her family's approval she followed her older sister to the University of Vienna, even to the extent of majoring in chemistry. However, Olga then switched her major to mathematics. Already intrigued by number theory, she took courses in the subject with Philipp Furtwängler who became her supervisor. Her thesis was in class field theory; it related p-groups and principal ideals. The D. Phil. in Mathematics was granted to her in 1930 by the University of Vienna.

She impressed another of her teachers in Vienna, Hans Hahn, who invited her to write a joint review of Volume I of B. L. van der Waerden's *Moderne Algebra* [*Monatshefte für Mathematik und Physik* 39 (1931), pp. 11–12; 40 (1932), pp. 3–4]. (The review of Volume II appeared only under her name.) What she learned about reviews from him served her well in the next sixty years of review writing—over 200 just in *Mathematical Reviews*, beginning with the first volume. Hahn recommended her to

Richard Courant of the famed Mathematical Institute in Göttingen who was looking for young people to help edit David Hilbert's *Gesammelte Abhandlungen* [Julius Springer, Berlin: 1932–1935]. In 1931–1932 she was an Assistant in Göttingen and helped edit the first volume, which was concerned with number theory. Olga also took shorthand notes of Emil Artin's lectures in class field theory and edited them. Emmy Noether offered a course in this area precisely because Olga was there, and provided opportunities for her to lecture. In addition, Olga agreed to help Courant in his differential equations course. Because of the growing political tension, he advised her not to return to Göttingen. (Courant was illegally dismissed by the Nazis on April 2, 1933, together with Emmy Noether and Max Born, later a Nobel laureate in physics.)

In 1932 Olga returned to Vienna where she was an assistant to Hahn and to Karl Menger, and also helped Furtwängler. Her small salary was supplemented with tutoring. Oscar Veblen, who had visited Göttingen when Olga was there, recommended her to Anna Johnson Pell Wheeler, chairperson of the Mathematics Department at Bryn Mawr, which offered her a scholarship for 1933–1934. Because of financial losses incurred in the Great Depression, the scholarship was canceled but was renewed as a "studentship" for 1934–1935. In the interim Olga had won a three-year science fellowship at Girton College, a women's college in Cambridge, which agreed to let her spend the first year at Bryn Mawr because Emmy Noether was there. Olga often accompanied Emmy to her lectures at Princeton. For Olga, Princeton was a dream come true; she was fascinated by the research there in topological algebra.

In June 1935 (after Noether's death), Olga returned to Girton College to spend the last two years of her fellowship. In 1937 she received an M.A., *ad eundem*, from Cambridge, after the rules were changed to permit a woman to be a degree recipient. Because she was "so deeply anxious to continue on topological algebra" [*Mathematical People: Profiles and Interviews* edited by Donald J. Albers and G. L. Alexanderson, pub. Birkhäuser, 1985, page 325], she missed opportunities to work with the distinguished mathematicians who were in Cambridge. One of them was Godfrey Harold Hardy who, together with the head of Girton College, recommended her in 1937 for a junior-level teaching position in one of the women's colleges of the University of London. The workload was very heavy. She made time to attend intercollegiate seminars, at one of which she met Jack Todd, who worked in analysis and was employed in a similar position, but with less arduous duties. He brought her a problem that she could not solve then (but later solved, with Ernest Best [*Proc. Royal Irish Academy* 47 (1942): 55–62] and it became a reason for them to get together. Olga and Jack were married in London on September 29, 1938.

War broke out less than a year later and life became very difficult. While waiting for war duties for Jack, they went to his parents' home in Belfast. It was here that they met the crystallographer and physicist, P. P. Ewald and his family; his mother, Clara P. Ewald, painted the portrait shown in this tribute. Later Jack was assigned to London and Olga to Oxford, where her college had moved to be safer from air raids. She supervised Hanna Neumann's thesis at Oxford.

From 1943 to 1946, while on leave from the University of London, Olga held a research position with the Ministry of Aircraft Production. She worked at the National Physical Laboratory with the so-called Flutter Group, directed by Robert A Frazer. Flutter concerns the self-excited oscillations of parts of a airplane. "It was impossible not to come under the spell of matrix theory in that group" [*Number Theory and Algebra*, edited by Hans Zassenhaus, pub. Academic Press, 1977, page xxxvii]. Olga succumbed to the spell of matrix theory, which became her major subject. She managed to bring into its arithmetical aspects her first love, number theory, including algebraic number theory, and introduced new, mainly non-commutative methods. Integral matrices were a favorite. Her interests in algebraic matrix theory included generalized commutativity and commutators. In analytic matrix theory she was one of the first to apply the Lyapunov theorem to study matrix stability. She was also one of the first to apply the Gerschgorin theorem to study a matrix with dominant main diagonal.

In 1947 Jack accepted an invitation to work for a year in the National Bureau of Standard's (NBS) field station, the Institute for Numerical Analysis at UCLA. Olga was invited to join the staff as Mathematical Consultant. Although John H. Curtiss, their boss, urged them to stay on, they returned to England for 1948–1949. They found life was still harsh there and decided to accept Curtiss's invitation to return, this time working in NBS headquarters in Washington, DC, until 1957. As consultant, Olga was kept very busy refereeing papers written by members and visitors, providing research problems, and working with young postdoctoral employees, among them Karl Goldberg (whose thesis at American University she supervised). She established a postdoctoral fellowship program, and also worked with high school students during the summer.

The Todds missed teaching. Hence, when Caltech made them offers in 1957, they readily accepted. Jack was offered a full professorship and Olga a research associate position, with the right but not the obligation to teach. In her most recent autobiographical account ["Zeitzeugin" in *Vertriebene Vernunft II: Emigration und Exil österreichischer Wissenschaft*, pub. Jugend und Volk, Wien, 1988, pp. 132–134], Olga wrote that it was not easy to decide on a position for her at a university which never before had women faculty. Olga took on teaching with some trepidation since she had long been away from the classroom. But her students were very helpful. "It was clear to them that I had much mathematics in me and they forced it out of me" (ibid). Her colleagues also were enthusiastic. Tom Apostol recalls how proud they were that someone of her stature and reputation joined their faculty, that she was the first woman to be appointed to Caltech, and later (in 1963) the first to be tenured. Olga was promoted to full professor in 1971, the first woman to hold this title in the Division of Physics, Mathematics and Astronomy.

She was selected in 1963 as one of nine Women of the Year by the *Los Angeles Times*. Under Fulbright Fellowships she and Jack spent a semester at the University of Vienna in 1965. They also spent a semester at the Courant Institute. Her paper on sums of squares in the *American Mathematical Monthly* [77 (1970): 805–830] won the Ford Prize for Mathematical Exposition from the Mathematical Association of America (MAA). Olga was on the Council of the London Mathematical Society in 1946–1947. She became a member of the Council of the American Mathematical Society in 1972 and served as Vice-President in 1985. She was elected Corresponding Member of the Austrian Academy of Science in 1975 and of the Bavarian Academy of Science in 1985. The Cross of Honor in Science and Arts, First Class, was bestowed upon her by the Austrian Government in 1978. The University of Vienna renewed her doctorate in 1980, awarding her the Golden Doctorate. An honorary Doctor of Science degree was conferred upon Olga by the University of California at Los Angeles (UCLA) in 1988 and she was elected a Fellow of the American Association for the Advancement of Science (AAAS) in 1991.

In 1976 many honors came to her on the occasion of her retirement. A symposium brought distinguished mathematicians to Caltech to honor her for her contributions. Two journals published special issues dedicated to her: *Linear Algebra and its Applications* [vol. 13 (1976)] and *Linear and Multilinear Algebra* [vol. 3 (1975–1976)]. She was a founding editor of the first and an editor of both journals. She was also an editor of *Journal of Number Theory* and of *Advances in Mathematics*. For several years she was Book Review Editor of the *Bulletin of the American Mathematical Society*. A book edited by Hans Zassenhaus [*Number Theory and Algebra*, pub. Academic Press, 1977] dedicated to Olga (and also to Henry Mann and Arnold E. Ross) contains her own technical survey of some of her work and her bibliography to date. Her publications for the next ten years are given in a chapter (by Edith H. Luchins) devoted to Olga in *Women of Mathematics: A Bibliographic Sourcebook* [edited by Louise S. Grinstein and Paul J. Campbell, pub. Greenwood Press, New York, 1987, pp. 225–235].

Caltech established in 1990 the Olga Taussky-John Todd Instructorships in Mathematics for mathematicians with strong research promise and not more than three years beyond the doctorate. Colleagues, friends, and students of the Todds contributed to the establishment in 1993 of the Olga Taussky-John Todd Lecture Program to invite (every three or four years) talented young mathematicians in linear algebra to talk about their research. The first lecture in the series was delivered in March 1993 at the ILAS meeting in Pensacola, Florida, by Helene Shapiro, who received her doctorate under Olga in 1979. We paraphrase her recollections in a recent telephone conversation:

On my first day as a graduate student at Caltech in January 1976, Professor Taussky came over to welcome me! The Todds had wonderful brunches to which they invited graduate students. In my second year I took Professor Taussky's year-long course, Advanced Matrix Theory. Topic oriented, it bridged the gap between course work and research. She was exuberant, fascinated with the way theorems developed, had a vast knowledge of the literature, and used a great many techniques from other areas, from algebra, geometry, number theory, and others. At the end of the course I asked if she would be my advisor and she agreed, recommending that I also take a less advanced matrix course with a colleague because he "does everything right." In my research, she insisted on my finding and citing the original sources. When I had some results, she announced, "That's enough for a thesis. Write it up."

Robert Guralnick, who worked with Olga on a postdoctoral appointment, recalled in an e-mail message in 1995: "I first met Olga Taussky in spring 1977 a few months before I started a two year appointment as a Bateman Research Instructor. Olga arranged that I get an office next to her and as soon as I arrived asked me to referee a paper for her. Over the next two years, I learned an enormous amount of matrix theory from her and through her seminar. I was very impressed by some of Olga's early matrix theory papers. In particular, her joint paper with Motzkin (L-property II) in the mid-50s was a tour de force and really introduced some new ideas; for example, they used algebraic geometry to study properties of matrices."

"Olga was very helpful to me throughout my career. She introduced me to many well-known mathematicians. She helped me in my appointment at USC and I am sure she was contacted about promotions. At USC, I would generally go to Caltech once a week to see Olga and attend her seminars. Olga was a very good friend as well. Every time I would visit her in her office she would offer me some candy, either European chocolate or a Kit Kat bar. She was an amazing lady—very frail looking but quite tough. I recall that she went on the Oberwolfach hike in 1984 and kept up with the group (at the age of 78)."

At Caltech Olga had 13 doctoral students. She was enormously supportive of them and of her postdoctoral associates. Philip Hanlon, her last Ph.D. student, remembered how dedicated she was as an advisor and what a kind and sensitive person she was, echoing the sentiment expressed by so many.

Dennis Estes, who as a postdoc worked with Olga in 1966, reminisced that she used to call her male Ph.D. students and postdocs her "boys" (cf. "Noether's boys" in *Emmy Noether: A Tribute to Her Life and Work*, edited by James W. Brewer and Martha K. Smith, pub. Marcel Dekker, 1981, page 83] and her "bad boys" if they did not contact her for a month or so. He will be discussing some of her work in a talk at a regional AMS meeting in Baton Rouge in mid-April. Bruce Reznick, who was an undergraduate at Caltech, sent an advance copy of his survey paper on Hilbert's 17th problem, which he has dedicated to the memory of Olga and of Raphael Robinson, both of whom contributed significantly to the topic, and both of whom unfortunately died in 1995.

Sadly Robert C. Thompson, one of Olga's first (1960) Ph.D. students at Caltech, whom she considered one of the two best, died (see below)only two months after his mentor, compounding the sorrow of the mathematical community in general and the linear algebra community in particular.

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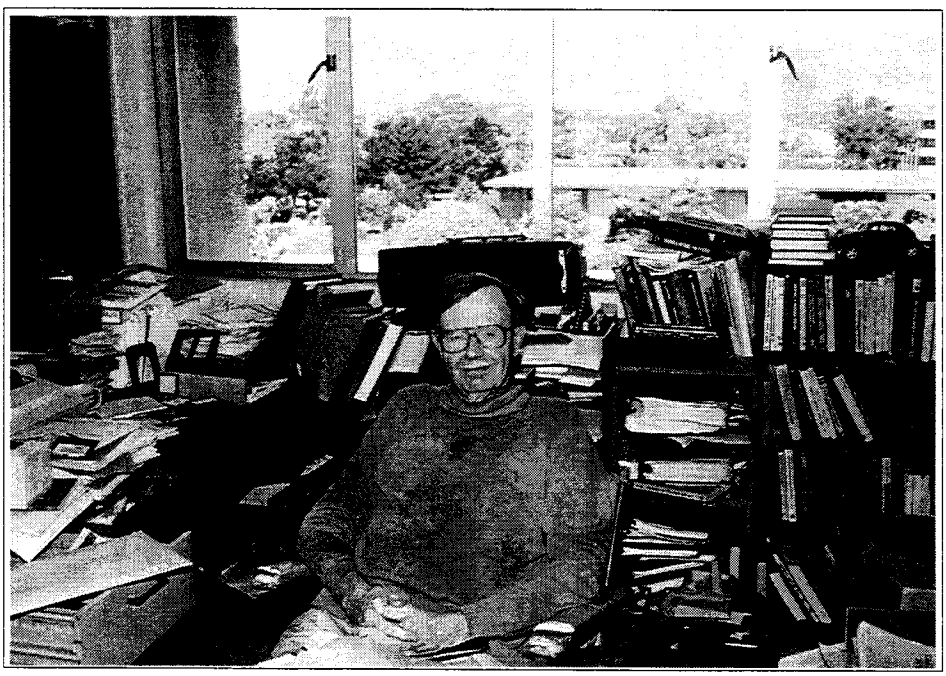
[Edith H. Luchins is advisor to Mary Ann McLoughlin, who is writing her doctoral thesis on the life and work of Olga Taussky Todd. They thank all who sent their reminiscences or advance copies of their articles. They note that Olga's writings are indexed under Olga Taussky, Todd, Taussky-Todd and Taussky Todd. In 1996 Jack Todd wrote "It was Otto Neugebauer who decreed the hyphenated name for *Mathematical Reviews* and only after a Caltech student complained that a result Olga said (in a lecture) was hers had been proved by a person called Taussky."]

Robert Charles Thompson: 1931–1995



Robert Charles Thompson, Professor of Mathematics at the University of California at Santa Barbara (UCSB), died on Sunday, December 10, 1995 while awaiting a heart transplant at the UCLA Medical Center in Los Angeles, California: he was 63.

Born in Vancouver, British Columbia, on April 21, 1931, Bob Thompson was a great mathematician and a very important and highly influential linear algebraist and matrix theorist. He has just been awarded the Second ILAS Hans Schneider Prize "for his lifetime achievement" in linear algebra" (page 8). And Bob was one of the founders of the International Linear Algebra Society and the first Editor of *Image*.

It was with great sorrow that I learned of his death. He was my Ph.D. thesis advisor, and my very dear friend. In August 1989, I went to UCSB from Beijing to work with Professor Thompson for my doctorate degree in mathematics. Professor Thompson's name had long been familiar to me before I became his student; he was an internationally well-known linear algebraist. In my four years of graduate study at UCSB, I learned so much from Bob and shared many pleasant times with him. By the time I graduated from UCSB Bob was truly a friend to me as well as a fine thesis advisor.

It all started in late 1987 with my paper on a singular value inequality concerning Hadamard products [*Linear and Multilinear Algebra* [22 (1988):307–311], in which a conjecture of Marcus, Kidman and Sandy was resolved. Soon after I submitted my manuscript to *Linear and Multilinear Algebra*, Professor Thompson (he and Marvin Marcus were then Editors-in-Chief of *Linear and Multilinear Algebra*) wrote to me in a very short letter that the conjecture had been solved by Ando, Horn, and Johnson [*Linear and Multilinear Algebra* 21 (1987): 345–365], and Okubo [*Linear Algebra and Its Applications* 91(1987): 13–28], but that "here is a problem of B. V. Lidskii you may try to solve", with Lidskii's paper [*Functional Analysis and Its Applications* 16 (1982):139–140] enclosed. I worked very hard on Lidskii's problem, but could not solve it—I then wrote to Professor Thompson asking if I could go to UCSB as his graduate student. He replied with one word, "Okay."

No sooner was I admitted to UCSB than I went to the library of Beijing Normal University to search for everything I could find about Professor Thompson. He had published many papers that I was not able to understand at that time. I saw a photo

of him for the first time in the book *Mathematical People: Profiles and Interviews* [edited by Donald J. Albers and G. L. Alexanderson, pub. Birkhäuser, 1985; the photo (on page 334) was taken at a 1976 symposium in honor of Olga Taussky Todd and also includes photos of Olga Taussky Todd, Richard Varga, Hans Schneider and David Carlson].

In the morning of September 8, 1989, my flight landed at Los Angeles International Airport, where Professor Thompson had been waiting for me for two hours because of a flight delay. As soon as I came out of the gate, I saw Professor Thompson holding a piece of paper with my name on it. After a brief greeting, he helped me pull the bigger luggage to the parking lot. Once we got out of the parking lot, he lost his way, and said to me "Don't worry, we will get to Santa Barbara."

Since then I met Bob nearly every day in his seminar, his office, or the Cafeteria "Harbor" downstairs in the Mathematics Department building, where Bob usually had a cup of coffee and a muffin about three o'clock in the afternoon. During my four years at UCSB, Bob's main research interests were on this problem of Lidskii's and on the quaternionic numerical range. These are extremely hard problems. I remember once in a conversation with Bob in his office, I asked him why he was so interested in these problems—he said that these were challenging problems. His research standards were extremely high. Among his many achievements, a very great effort resulted in the fifty-two page manuscript "On the spectral set for a sum of Hermitian matrices," co-authored with Jane Day and Wasin So, 1991; "The numerical range of normal matrices with quaternion entries," with Wasin So and me [*Linear and Multilinear Algebra* 37 (1994):175–195], and the sixty-five page manuscript "Convexity of the upper complex plane part of the numerical range of a quaternionic matrix", with Wasin So, 1995.

Bob was an authority on linear algebra and on matrix theory. He helped me enormously through my graduate study. Every time I got stuck in my research, I went to him and he always gave me some valuable comments and suggestions. His knowledge was encyclopedic. He even sometimes showed me how to revise and polish a manuscript. The first paragraph of my note "A trace inequality for unitary matrices" [with Bo Ying Wang, *American Mathematical Monthly* 101 (1994):453–455], was really written by Bob!

Bob was a very hardworking person. He spent more time in his office than at home. He often worked until two or three o'clock in the morning. Asked "Why work so hard?" he smiled and said, "Since I am not smarter, I work harder." Once when we talked about retirement and benefits, he said he would never retire.

There is so much to recall about Bob. He was a fine man and an excellent mathematician. His death is a tremendous loss to all his relatives, friends, colleagues, the international linear algebra community, and the International Linear Algebra Society. He will not soon be forgotten by the many who admired and respected him. His remarkable and profound results are great contributions to mathematics.

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Bill Larry Neal: 1944–1995

Bill Larry Neal died on Monday, October 16, 1995, at the age of 51, after a nine-year battle with cancer, that was fiercely fought. Born in Jackson, Mississippi, on January 22, 1944, he had been a member of the faculty at East Tennessee State University for 12 years and an ILAS member for the past 2 years. He held appointments in both the Computer and Information Sciences Department and the Mathematics Department. Larry made major contributions to the field of physiology and 0-gravity effects at NASA. All of us who knew Larry thought a lot of him and will miss his smiling face. The following poem was given at his "Service of Remembrance and Celebration of Life."

God saw he was getting tired,
and a cure was not to be;
So he put his arms around him,
And whispered, "Come with me."

With tearful eyes we saw him suffer,
and watched him slip away;
Although we loved him dearly,
we could not make him stay.

A golden heart stopped beating,
creative hands to rest;
God touched our hearts to prove to us,
He only does what's best
... and only takes the Best!!!

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[Larry Neal attended the ILAS meeting in Atlanta last August 1995. At the meeting he presented a very nice paper (joint work with George Poole) on a new pivoting strategy, called "Rook's Pivoting". Larry was also one of the participants in the ATLAST Developers Workshop. His contributions to the ATLAST Project were significant. Despite a losing battle with cancer Larry was able to remain active in the linear algebra field right up to the very end. Those who knew Larry personally will miss him very much.–Ed.]

On Leaving the President's Chair

When a few of us met in Victoria, British Columbia, in 1987 and decided to start the International Matrix Group, I had little expectation that within two years this Group would become the formally incorporated International Linear Algebra Society (ILAS). Even less did I realize that eight years later we would have several hundred members, an extensive electronic information service and database, regular and successful meetings, an impressive newsletter—*Image*—and now even an electronic research journal (ELA). I think I was one of the more skeptical founders at Victoria; in retrospect, it is clear that those, who felt (and Bob Thompson was prominent among them) that an independent linear algebra organization was viable and beneficial to the field, were absolutely right. The Society has been successful because those working in the field have supported it and a fairly sizable group of linear algebraists have worked hard for it.

The rest of this article will not recount the history of the ILAS—it is too early for that. Instead, I'd like to describe some of my attitudes as president which may not have been obvious to most of the members. I'd like to mention two points here.

Many mathematical meetings depend on support from granting agencies such as NSF in this country. I felt that, while we should actively seek financial support from granting agencies, we should attempt to be as independent of outside support as possible. After all, at least in the United States, agency support for meetings has declined and it may cease entirely. But ILAS meetings must still continue even then. As a result, ably supported by our treasurer, James Weaver, I've advocated a very conservative financial policy. Using our modest dues and helped by several donations, we have managed to build up reserves which may stand us in good stead.

All of us are aware that there are informal groups in mathematics, usually built around one or more outstanding individuals in a field, which hold periodic meetings. But I wished ILAS to survive the original group of founders. As a result I favored a certain legalism and I wished to determine the activities of the Society by written rules such as bylaws. For example, ILAS has precise rules for the election to its Board of Directors. Note that both of these principles (if that's what they are) aim at establishing a society that has permanence.

There is another issue that I wish to discuss. When I became President of ILAS, I determined that each activity of the society should support other activities. In the course of events, it became clear to me that there is a price to be paid, for then it is impossible merely to consider how to perform each activity optimally. For example, we founded ILAS to run low cost meetings and we have kept registration fees low. But it would have been possible to have even lower registration fees in some instances had we not wished to safeguard our reserves and (at an early stage) support *Image*. Similarly, if one were merely producing an electronic journal by voluntary labor one might allow universal free access; in fact we decided to restrict access to members of the society in the hope that this might encourage some new members. The price was worth paying, for in this way we have built a team that thinks in terms of our Society, not one group that wishes the Society's limited resources to be spent on meetings, another on *Image* and a third on ELA, and so on.

At least one factor distinguishes our Society from larger ones such as SIAM or AMS: we have no paid staff—all work done for this Society (with very minor exceptions) is on a voluntary basis. For other societies, a repetitive job, such as the production and mailing of a flier announcing a meeting, may be a project assigned to a paid secretary; for us it requires volunteer labor. It is remarkable that such volunteers have always been found. All who have worked on our meetings, our journals and our committees deserve my thanks to the greatest extent. It is unfortunately impossible for me to list and thank all individually. However, I must acknowledge the immense contributions to this Society of two members of the original ILAS executive without whose devotion and many hours of work the Society could not have flourished: Daniel Hershkowitz and Jim Weaver.

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The Hans Schneider Prize in Linear Algebra

On the recommendation of the ILAS Linear Algebra Prize Committee, the ILAS Executive Board has awarded the Second Hans Schneider Prize in Linear Algebra to Robert C. Thompson (1931–1995) posthumously for his lifetime achievement and to Mike Boyle and David Handelman for their solution of the inverse eigenvalue problem for nonnegative matrices (in particular their outstanding paper "The spectra of nonnegative matrices via symbolic dynamics", *Annals of Mathematics* 133 (1991): 246–316). The Prize Committee consists of: Daniel Hershkowitz (chair), Richard A. Brualdi (ILAS President), Shmuel Friedland, Thomas J. Laffey, Peter Lancaster, and Hans Schneider (ILAS Past President).

The Hans Schneider Prize in Linear Algebra is awarded by the International Linear Algebra Society (ILAS) for research contributions and achievements at the highest level in Linear Algebra. The Prize may be awarded for an outstanding scientific achievement or for lifetime contribution. The Prize is awarded every three years at an appropriate ILAS meeting, as decided upon by the ILAS Executive Board. In any year in which a Prize is awarded, there may be more than one recipient, within the discretion of the Board. The first prize was awarded jointly to Miroslav Fiedler, Shmuel Friedland and Israel Gohberg in 1993.

Procedure for determining the winner. A Prize Committee is established by the ILAS President upon the recommendation of the ILAS Executive Board. The Committee solicits nominations from members of the linear algebra community of people of outstanding achievement in the subject and the Committee makes recommendations to the ILAS Executive Board, which then makes the award. (There shall be no restrictions on whom shall receive the Prize based on sex, race, national origin, age or the time since the recipient took his or her last academic degree). The recipient is notified at least two months prior to the ILAS meeting at which the Prize is to be presented and is also invited to give a talk at that meeting.

Nature of the Prize. The Prize consists of a plaque and a certificate containing the citation. The Executive Board may also decide to make a cash award to the recipient and/or make a contribution towards the expenses incurred in attending the award ceremony.

Funding. The funding for the Prize comes from the interest accruing on a large donation made to ILAS by Hans Schneider and a number of small contributions from other people.

Selected Forthcoming Linear Algebra Events

ILAY Workshop on Linear Algebra in Optimization

Albi, near Toulouse, France: April 22–25, 1996

This is the third in a series of four workshops, which are a part of the CERFACS International Linear Algebra Year held in the picturesque town of Albi, near Toulouse in South-West France, April 22–25, 1996. This workshop is devoted to Linear Algebra in Optimization. The first day and a half of the workshop will be a tutorial introduction to optimization methods, while the remaining two and a half days will be dedicated to invited and contributed talks addressing research topics. A preliminary list of invited speakers for the workshop includes: A. Björck (Sweden), A. Conn (USA), Yu. Evtushenko (Russia), R. Fletcher (UK), A. Griewank (Germany), C. Lemarechal (France), J. More (USA), W. Murray (USA), J. Nocedal (USA), M. Powell (UK), R. Schnabel (USA), D. Shanno (USA), and Ph. Toint (Belgium). The local organizing committee comprises O. Burdakov (CERFACS), M. Dayde (ENSEEIHT-IRIT), I. Duff (CERFACS and RAL) and N. Gould (RAL). A limited number of contributed 20 minute talks will be selected for the workshop, and suitable contributions are solicited. Because of support, the cost of the workshop has been kept to 1500 FFR (which includes registration, documentation, lunches, tea and coffee), with a reduction to 1000 FFR for full-time students, and a fee of 3000 FFR for non-academics. There are many reasonably-priced hotels close to the workshop site.

Up-to-date information on the workshop (including the abstracts of talks, registration forms, etc.) can be found via the WWW page `http://www.cerfacs.fr/~wlay/LAY/lay.html` or directly from the Secrétariat de l'Année Internationale de l'Algèbre Linéaire, Parallel Algorithms Project, CERFACS, 42 Avenue Gustave Coriolis, F-31057 Toulouse, CEDEX, France; FAX (33) 61.19.30.00, `rault@cerfacs.fr`.

3rd Western Canada Linear Algebra Meeting

Kananaskis Village, Alberta: June 10–11,1996

A regional meeting on linear algebra and related fields will be held June 10–11, 1996, at Kananaskis Village, 80 kilometres west of Calgary, Alberta, in the eastern slopes of The Rocky Mountains. This meeting will be the Third Western Canada Linear Algebra Meeting (W-CLAM), the first two having been held in Regina and Lethbridge. The purpose of W-CLAM is to draw together researchers in linear algebra and related fields to present accounts of their recent work and to facilitate discussions on matters of relevance to them. Participation is open to anyone who is interested in attending or speaking at the meeting. The organizers can provide no financial support for participants. Immediately prior to W-CLAM '96, the Canadian Mathematical Society (CMS) with hold its 1996 Summer Meeting in Calgary, June 7-9, 1996, in which there will be a session on Matrix Analysis. The timing and locale of W-CLAM provides interested participants the occasion to attend two meetings, should they wish to do so. Please note that the CMS and W-CLAM meetings are entirely separate entities, each with its own organizing and arrangements committee. (For details of the CMS meeting write to the CMS, 577 King Edward, P. O. Box 450, Station A, Ottawa, Ontario, Canada K1N 6N5; exsm@acadvm1.uottawa.ca.)

All talks are contributed and will be about 30 minutes in length. Speakers need not be from Western Canada, although we encourage, in particular, regional participation. The meeting will be held at The Kannanaskis Inn, Kannanaskis Village, Alberta, Canada T0L 2H0; tel. (1-403) 591-7500, FAX (1-404) 591-7633. The cost of accommodation is C$99 (plus 12% tax) per night for either single or double occupancy including breakfast. Participants are asked to make their own accommodation arrangements with the hotel, referring to "W-CLAM" and Reservation Number 116803 in their correspondence. A shuttle service between Calgary and Kannanaskis Village will be available at cost with details to be announced at a later date. There is a C$20 registration fee, payable by cash or cheque at the meeting, to offset the cost of the conference room of the hotel. A call for abstracts will be given in a second announcement. The registration and scheduling of talks will be handled by Doug Farenick and Steve Kirkland, and so abstracts should be directed to either one of them. Organizers: Peter Lancaster, Dept. of Mathematics & Statistics, University of Calgary, Calgary, Alberta, Canada T2N 1N4; lancaste@acs.ucalgary.ca, tel. (1-403) 282-5150; Doug Farenick and Steve Kirkland, Dept. of Mathematics & Statistics, University of Regina, Regina, Saskatchewan, Canada S4S 0A2; farenick@abel.math.uregina.ca, tel. (1-306) 585-4425; kirkland@max.cc.uregina.ca, tel. (1-306) 585-4352.

ATLAST 1996 Linear Algebra Workshops

Newport, Rhode Island: June 12–15; La Jolla, California: July 24–27,1996

ATLAST is an NSF Project to Augment the Teaching of Linear Algebra through the use of Software Tools. The project will offer two faculty workshops on the use of software in teaching linear algebra during the summer of 1996. Workshop participants will learn about existing software for linear algebra and will be trained in the use of the MATLAB software package. Attendees will design classroom lessons that incorporate computer software making use of ATLAST materials that were developed in previous workshops. These materials will be included in the forthcoming *ATLAST Book of Computer Exercises* (Prentice-Hall, Fall, 1996). Participants will also learn to design computer exercises and lab projects for inclusion in the ATLAST database and possible inclusion in future editions of the ATLAST book. The ATLAST Project provides room and board for participants attending the workshops. The project was conceived by the Education Committee of the International Linear Algebra Society (ILAS).

Image Joint Editor Steven J. Leon of the ILAS Education Committee is serving as the ATLAST Project Director and the Assistant Director is Richard Faulkenberry. Both are in the Mathematics Department of the University of Massachusetts–Dartmouth. The ATLAST project is funded by a National Science Foundation Faculty Enhancement grant. This is the fifth year of ATLAST workshops. Over 350 faculty members have participated in the twelve workshops given during the summers of 1992, 93, and 95. A number of these participants were invited to attend an advanced workshop in 1994. A second advanced workshop will be held at the University of Washington, Seattle, August 13-16, 1996. Workshop evaluations and follow-up surveys clearly show that the ATLAST program has been a rousing success. We are confident that the '96 workshops will be equally well received.

The First Summer 1996 ATLAST Workshop will be held at the Salve Regina University, Newport, Rhode Island, June 12–15, 1996; the Workshop Presenter is Steven J. Leon (University of Massachusetts–Dartmouth). The Second Workshop will be held at the University of California–San Diego, La Jolla, California, July 24–27, 1996; the Workshop Presen-

ter is Lila Roberts (Georgia Southern University, Statesboro). All teachers of undergraduate linear algebra courses at colleges or universities in the USA are invited to apply for the ATLAST workshops. The deadline for applications is March 21, 1996. Late applications will be accepted on a space available basis. Each workshop will be limited to thirty participants. A screening committee will review applications and notify applicants of its decisions by the beginning of April. For further information on applying see the ATLAST web page: `http://tango.mth.umassd.edu/ATLAST/ATLAST.html` or contact: *Image* Joint Editor Steven J. Leon, ATLAST Project Director, Department of Mathematics, University of Massachusetts–Dartmouth, Old Westport Road, North Dartmouth, MA 02747-2300, USA; tel. (1-508) 999-8320, FAX (1-508) 999-8901, `ATLAST@UMASSD.EDU`.

13th Householder Symposium on Numerical Algebra

Pontresina, Switzerland: June 17–21, 1996

The 13th Householder Symposium on Numerical Algebra will be held at the Hotel Kronenhof in Pontresina, Switzerland, Monday–Friday, June 17–21, 1996. More complete information about the meeting and the Householder Prize can be found at the Website `http://www.cs.umd.edu/users/oleary` and these files are also available via ftp from `cs.umd.edu` in directory `pub/faculty/oleary`. This meeting is the thirteenth in a series, previously called the Gatlinburg Symposia. The name honors Alston S. Householder, one of the pioneers in numerical linear algebra and organizer of the first four meetings. The meeting has traditionally been held in an isolated location and is very informal in style. Each attendee is given the opportunity to present a talk, but a talk is not mandatory. The format of the meeting includes scheduled presentations during the day and more informal evening sessions that are organized on-site. Spirited discussion is encouraged.

At the meeting, the Householder VII prize will be awarded for the best thesis in numerical algebra written since 1 January 1993. We hope that the meeting will be attended by recent entrants into numerical algebra as well as more experienced researchers. We encourage attendance by core numerical linear algebra researchers, matrix theoreticians, and people in applications such as optimization, signal processing, control, etc. The Program Committee welcomes your contribution. The meeting facility in Pontresina holds only 125 people, however, so attendance may need to be limited. We are seeking funding to provide financial assistance to recent PhDs and others who might need it. For full consideration, the committee must receive your abstract by 5 January 1996. Please use the format described in the "abstract" file on the Website and ftpsite. The committee expects to complete the list of attendees and scheduled presentations by 15 February 1996. After reading the files in the Website or ftpsite, if you have any questions about local arrangements, please contact Martin Gutknecht: `mhg@ips.id.ethz.ch`. Other questions can be directed to `house-request@cs.umd.edu`. The Program Committee comprises: A. Björck, A. Bunse-Gerstner, T. Chan, C. Davis, A. George, N. Higham, D. O'Leary (chair), B. Parlett, G. W. Stewart, P. Van Dooren, C. Van Loan, M. Gutknecht (ex officio), W. Gander (ex officio).

1st Workshop on Numerical Analysis and Applications

Russe, Bulgaria: June 24–27, 1996

Traditionally every 4 years a Conference on Numerical Analysis and Applications is organized in Bulgaria. The present workshop is meant to support this tradition and to serve as an intermediate meeting between these conferences. We would like to give an opportunity for mathematicians and applied scientists to discuss topics of common interest. Organizers: University of Russe, Association of Bulgarian Mathematicians–Russe; Co-organizers: Institute of Mathematics and Center for Informatics and Information Technologies of the Bulgarian Academy of Sciences, Technical University of Gabrovo, Technical University of Sofia, University of Texas of the Permian Basin In cooperation with: ACM Special Interest Group on Numerical Mathematics Society for Industrial and Applied Mathematics.

The workshop will have four tracks: 1. Numerical Linear Algebra. 2. Numerical Methods for Differential Equations. 3. Numerical Modeling. 4. High Performance Scientific Computing. Preliminary list of Invited Speakers: R. Bisseling (Netherlands), L. Brugnano (Italy), E. Dyakonov (Russia), I. Gladwell (USA), S. K. Godunov (Russia), A. Griewank (Germany), S. Hammarling (UK), W. Hofmann (Germany), B. Jovanovich (Yugoslavia), A. Karageorghis (Cyprus), Yu. A. Kuznetsov (Russia), R. Maerz (Germany), W. T. Pickering (UK), R. Plemmons (USA), G. I. Shishkin (Russia), I. Siliciu

(Romania), T. Szulc (Poland), E. E. Tyrtyshnikov (Russia), P. Vabishchevich (Russia), W. Varnhorn (Germany), V. V. Voevodin (Russia), Z. Zlatev (Denmark). Organizing committee: L. Vulkov (Chair), P. Yalamov (co-Chair), A. Andreev, P. Ivanova, I. Lirkov, M. Paprzycki, V. Pavlov, S. Romanova, T. Todorov, Z. Trzaska, K. Zlateva, J. Wasniewski. We would like to invite all interested individuals to organize minisymposia and contribute papers related to one or more of the conference tracks. Please send a minisyposium abstract (approximately one page) and a list of 4-8 speakers. To contribute a paper send an extended abstract (approximately one page). Direct all correspondence to: Plamen Yalamov, Dept. of Mathematics, University of Russe, BG-7017 Russe, Bulgaria; yalamov@iscbg.acad.bg, or to Marcin Paprzycki, Dept. of Math. & Computer Science, Univ. of Texas–Permian Basin, Odessa, TX 79762; paprzycki_m@gusher.pb.utexas.edu.

5th International Workshop on Matrix Methods for Statistics

Shrewsbury, Shropshire, England: July 18–19, 1996

The 5th International Workshop on Matrix Methods for Statistics will be held in Shrewsbury, Shropshire, England, on Thursday–Friday, July 18–19, 1996. Previous workshops were held in Tampere, Finland, August 1990; Auckland, New Zealand, December 1992; Tartu, Estonia, May 1994, and Montréal, Québec, Canada, July 1995. The purpose of these workshops is to stimulate research on matrix methods and their applications in statistics and to encourage informal discussion of topics of mutual interest within this subject area. Shrewsbury is an ancient market town situated in an almost circular bend of the river Severn on the Welsh boarder of England. The 12th Century town will be familiar to many as the setting for the Brother Cadfael mystery stories of Ellis Peters, but the town and its environs contain architectural memorials of all ages. Although there is much to see in the town, participants are advised that they will find a Roman settlement and vineyard, manor houses, stately homes and gardens and beautiful open countryside in the immediate neighbourhood. Those with more time to spare may wish to take the opportunity to explore Wales and the West of England.

The Workshop will be held in the Gateway Centre for Education and Art, situated just outside the town centre about 200 metres (220 yards) from the bus and railway stations. Lunches may be taken in the Gateway or at a wide range of establishments within easy walking distance. There is a wide variety of accommodation within the town and its immediate environs. The Workshop organisers will attempt to negotiate special rates at the major hotels in the town centre for those participants wishing to stay at these hotels. However, participants travelling by car may wish to stay at the smaller hotels and guest houses around the town. Such participants should book their own accommodation by contacting the telephone or FAX numbers listed in "Where to Stay in Shrewsbury". This brochure will be sent to you by post if you are not able to obtain a copy from your local travel agent. Bed and breakfast accommodation with private families is also available but must be reserved well in advance of the workshop. All town accommodation is within walking distance of the Gateway or on a good bus route.

A reception will be held on Wednesday, 17 July 1996. Persons registering for the workshop may participate without further charge. Please indicate the number of persons likely to accompany you to this reception. At present we do not intend to levy a charge for accompanying persons. A formal Workshop dinner will be held on Thursday, 18 July 1996. The cost of this is UK£25 per person to include travel, welcome drink and three course dinner with wine or fruit juice. Please advise the organisers of any special dietary requirements. An evening visit to the Roman Vineyard at Wroxeter followed by a light supper will be arranged for the evening of Friday, 19 July 1996. The charge for this trip is UK£10 and includes wine tasting, supper and travel. Wroxeter is now known to have been the most important military base in the west of Britain before the foundation of the legionary camp at Chester in AD 78.

Abstracts of papers to be presented at the Workshop should be sent to the organisers at one of the following addresses either in the form of a typescript or in LATEX by 30 April 1996. Abstracts should be preceded by a title and a full list of authors and followed by the full postal and e-mail addresses of one of the authors. An early indication of possible titles would be appreciated. The registration fee for regular participants is UK£35. Retired persons may pay a lesser fee of UK£25 and students a fee of UK£15. Students should submit a letter from their supervisor confirming their status. A late registration fee of UK£10 will be levied an all participants other than students registering after 31 March 1996. If at all possible we should like to have clear indications of the number of participants by the beginning of April 1996 in order that we may secure appropriate facilities at the Gateway Centre. Payment should be made in British pounds sterling (GBP/UK£) by means of a cheque drawn on a British bank in favour of R. W. Farebrother. Alternatively payment may be made in British pounds by means of a bank giro credit payable to the account of R. W. Farebrother at the Royal Bank of Scotland, 6 The Square, Shrewsbury (Bank Sort Code 16-31-23, Account Number 10015581). This is an account opened for the specific purposes of the Workshop and all transactions will be open to the inspection of the Organising Committee. Participants from Western

Europe, Canada, United States of America, Japan, Australia, and New Zealand may pay by personal cheque. Add UK£5 to the total on the Registration Form to cover bank charges and divide the result by the current exchange rate for buying pounds sterling. A cheque for this amount payable to R.W. Farebrother should be sent to the organisers. The organisers apologise to participants from other countries but bank charges make it impracticable to extend this scheme to them. We regret that it is not possible to accept payment of Registration fees by credit card. Workshop Office Address: 11 Castle Road, Bayston Hill, Shrewsbury, Shropshire SY3 0NF, England, United Kingdom. Messages may also be sent by e-mail to: r.w.farebrother@man.ac.uk or by FAX to (44-161) 275-4812 (e-mail preferred).

6th Conference of the International Linear Algebra Society

Chemnitz, Germany: August 14–17, 1996

The Sixth Conference of the International Linear Algebra Society (ILAS) will be held at the Technische Universität Chemnitz-Zwickau in Chemnitz, Germany, August 14–7, 1996. The Organizing Committee comprises: B. De Moor (Catholic Univ. of Leuven), G. De Oliveira (Univ. Coimbra), L. Elsner (Univ. Bielefeld), T. Laffey (Univ. College Dublin), V. Mehrmann (TU Chemnitz—Chair); G. Michler (Univ. GH. Essen), M. Neumann, (Univ. of Connecticut), F. Uhlig (Auburn University). The Local Arrangements Committee: D. Happel, F. Lowke, C. Rost, B. Silbermann.

The purpose of this conference is to bring together researchers and educators in all fields of Linear Algebra from Numerical Linear Algebra to Algebra, pure ad applied, allowing a broad exchange of ideas and discussion of recent developments in these areas. Special emphasis: Numerical Linear Algebra, Computational Algebra.

List of invited speakers: Olga Taussky-Todd speaker: R. Guralnick, Los Angeles; Hans-Schneider Prize speaker: TBA. 50 minute-invited speakers: J. Demmel, Berkeley (tentative); J. Dorier, Univ. Pierre Mendes (tentative); C. Ringel, Bielefeld; P. Van Dooren, Louvain La Neuve; U. Helmke, Würzburg; D. Hershkowitz, Haifa; R. Bapat, New Delhi. 30 minute-invited speakers: L. Berg, Rostock; R. Byers, Lawrence; M. Eiermann, Freiberg; R. Gow, Dublin; C. Li, Williamsburg; N. Nichols, Reading; R. Matthias, Williamsburg (tentative); T. Pate, Auburn; F. Hall, Atlanta. Minisymposia: G. Michler, Essen: Parallel Computations in Algebra; B. Silbermann, Chemnitz: C*-algebra techniques in computational linear algebra; R. Horn, Salt Lake City: Canonical forms; N. Higham, Manchester: Perturbation Theory. After-dinner speaker: B. Huppert (tentative). For further information contact: Heike Weichelt, TU Chemnitz-Zwickau, Fakultät für Mathematik, D-09107 Chemnitz, Germany; hweichel@mathematik.tu-chemnitz.de, tel. (49-371) 531-2659, FAX (49-371) 531-2657.

2nd International Workshop on Total Least Squares and Errors-in-Variables Modeling

Leuven, Belgium: August 21–24, 1996

This interdisciplinary workshop is a continuation of a previous workshop on "Total Least Squares: Concepts, Algorithms, Applications" which was held in Leuven, Belgium, August 1991, and aims to bring together numerical analysts, statisticians, engineers, economists, chemists, etc. in order to discuss recent advances in Total Least Squares (TLS) techniques and errors-in-variables modeling. Papers are solicited for technical sessions on the following and related topics: TLS Concepts and Properties: structured and constrained TLS, other norms, nonlinear errors-in-variables, curve fitting, statistical, numerical, robustness and optimization aspects TLS Algorithms: real-time, adaptive, recursive, iterative algorithms, based on SVD or related decompositions, architectures, complexity, accuracy, regularization, convergence TLS Applications: array signal processing, model identification, spectrum analysis, harmonic retrieval, direction finding, geology, chemistry In particular, overview papers describing recent advances on any of the above-mentioned topics are invited. Other topics related to TLS, errors-in-variables modeling, and their applications are also welcome. Authors are invited to submit four copies of an extended summary (2–4 pages) to the workshop secretariat for review. Fax number and e-mail should be provided if possible. Overview papers will be presented as lecture, the other ones in poster form. Authors of accepted contributions will be asked to prepare a version for publication in the conference proceedings. Conference committee: Sabine Van Huffel (chair), Bart De Moor, Wayne Fuller, Leon Gleser, Gene Golub, Bjørn Ottersten, Pete Stewart. Workshop secretariat: Ida Tassens Dept. of Electrical Engineering, ESAT/SISTA, Katholieke Universiteit Leuven, Kardinaal Mercierlaan 94, B-3001 Leuven-Heverlee, Belgium; ida.tassens@esat.kuleuven.ac.be, tel. (32-16) 32.17.09, FAX (32-16) 32.19.86.

2nd SIAM Conference on Sparse Matrices

Cœur d'Alene, Idaho: October 9–11, 1996

The 2nd SIAM Conference on Sparse Matrices will be held at The Cœur d'Alene Resort, Cœur d'Alene, Idaho, October 9-11, 1996. The organizers are: Esmond G. Ng (Oak Ridge National Laboratory) and Daniel J. Pierce (The Boeing Company). The Program Committee comprises: Åke Björck, Linköping University, Sweden; Iain S. Duff, Rutherford Appleton Laboratory, United Kingdom and CERFACS, France; Roland W. Freund, AT&T Bell Laboratories; J. Alan George, University of Waterloo, Canada; John R. Gilbert, Xerox Palo Alto Research Center; Gene H. Golub, Stanford University; Esmond G. Ng, Oak Ridge National Laboratory; Daniel J. Pierce, The Boeing Company; Horst D. Simon, Silicon Graphics Computer Systems. The organizers and program committee will be inviting three plenary speakers to give presentations on current sparse matrix research. The information will appear in the conference program which will be available in mid-July, 1996. The Conference Themes are: Applications, Iterative Methods for Non-Hermitian Matrices, Parallel Sparse Direct Methods, Preconditioning Techniques, Sparse Eigenvalue Computations, Sparse Methods in Optimization, Sparse Regularization and Rank-Deficient Methods, Structured matrices.

The field of Sparse Matrices is a broad and important area of the computational sciences that includes structured matrices and those with seemingly little or no structure. The relevance of the field is highlighted by the wide range of application areas that require the exploitation of matrix sparsity/structure in order to achieve a solution given real world constraints on computing resources and/or time. This 2nd SIAM Conference on Sparse Matrices will bring together scientists working in the field of sparse matrix computations and those formulating problems resulting in sparse matrix problems. The intent is to provide a venue for the exchange of problems, ideas, new results and a discussion of future trends.

The program committee invites you to participate in this exciting conference by submitting an extended abstract not more than one page in length. The abstract should include the title, the author's name, mailing address, e-mail address, and the name of speaker (if jointly authored). Please include a list of keywords (at most 5) in order of importance. Electronic submissions are encouraged. If you need a LaTeX macro to format your one-page, single-spaced extended abstract, send your request for a macro to `meetings@siam.org`. Completed abstracts should be sent to each of the following: `meetings@siam.org`, `esmond@msr.epm.ornl.gov`, `dpierce@espresso.rt.cs.boeing.com`, and should arrive on or before April 15, 1996, to be considered for presentation. The committee will select from the abstracts, long presentations (1 hour) and short presentations (30 minutes). The meeting will be similar to that of the 1989 SIAM Symposium on Sparse Matrices. This will be a 3-day meeting. There will be about six 1-hour talks that will NOT occur in parallel and short presentations (30 minutes each) scheduled in parallel. We expect to limit the number of parallel sessions to three. The conference will be held at The Cœur d'Alene Resort in Cœur d'Alene, Idaho. The resort is located right on Lake Cœur d'Alene among the Bitterroot Mountains of Northern Idaho. It is 45 minutes by car from Spokane International Airport in Spokane, Washington. In early October the days should be sunny and the nights cool and clear. Information regarding the conference can be accessed through the World Wide Web: `http://www.siam.org/conf.htm`.

International Linear Algebra Society Symposium: Fast Algorithms for Control, Signals and Image Processing

Winnipeg, Manitoba, Canada: June 6–9, 1997

There will be an International Linear Algebra Society (ILAS) Symposium on "Fast Algorithms for Control, Signals and Image Processing" in Winnipeg, Manitoba, Canada, June 6-9, 1997. The Symposium host is the University of Manitoba Institute of Industrial Mathematical Sciences, P. N. Shivakumar, Director. The Organizing Committee: P. N. Shivakumar (Manitoba—Chair), Pauline van den Driessche (Victoria), Tom Kailath (Stanford), Peter Lancaster (Calgary), Dianne O'Leary (Maryland), Bob Plemmons (Wake Forest), Hans Schneider (Wisconsin). The Program Committee: Moody Chu (NCSU), Biswa Datta (NIU), Brent Ellerbroek (Air Force Phillips Lab), Georg Heinig (Kuwait), Franklin Luk (RPI), Dianne O'Leary (Maryland—co-chair), Haesun Park (Minnesota), Bob Plemmons (Wake Forest—co-chair), Ali Sayed (UCSB), Hans Schneider (Wisconsin), P. N. Shivakumar (Manitoba), Paul Van Dooren (Belgium).

The meeting will overlap with a meeting in Winnipeg by the Canadian Mathematical Society (CMS). The dates for our Symposium, including interaction with the CMS, are: June 6 : ILAS Short Course: A full day with speakers on topics related to the symposium themes of Control, Signals and Image Processing. This ILAS Short Course will be available to the participants of CMS Meeting. June 7–8: ILAS Symposium: Invited speakers, invited minisymposia, contributed minisym-

posia and contributed paper sessions. June 9 : CMS Workshop: A full day seminar on Linear Algebra organized by P. N. Shivakumar and a CMS committee with ILAS participation. This CMS Workshop will be available to the participants of ILAS Symposium. We expect a blend of application-oriented talks, along with talks on general linear algebra relating to the Symposium themes. Participation by researchers from Industry and from Government Laboratories is encouraged. For program information please contact Dianne O'Leary: oleary@cs.umd.edu, or Robert J. Plemmons, Computer Science Dept., Box 7388, Wake Forest University, Winston-Salem, NC 27109, USA; plemmons@mthcsc.wfu.edu, tel. (1-910) 759-5358, FAX (1-910) 759-7190, WWW http://www.wfu.edu/~plemmons.

International Calendar of Events in Linear Algebra & Related Topics

1996

April 13: Ottawa, Ontario. Discrete Mathematics Day. Lieven Vandenberghe: Determinant maximization under linear matrix inequality constraints. Carleton University.

April 13: Pasadena, California. One-Day Symposium in Honor of Olga Taussky Todd (1906–1995). California Institute of Technology. [Marge D'Elia, Dept of Mathematics 253-37, California Institute of Technology, Pasadena, CA 91125; delia@cco.caltech.edu]

April 22–25: Albi, near Toulouse, France. ILAY Workshop on Linear Algebra in Optimization. [CERFACS, 42 Avenue Gustave Coriolis, F-31057 Toulouse, CEDEX, France; FAX (33) 61.19.30.00, rault@cerfacs.fr] *See Image 16:8.*

May 20–22: Victoria, British Columbia. Triennial SIAM Meeting on Optimization. [B Buckley, Dept of Mathematics, Royal Roads Military College, FMO Victoria, BC V0S 1B0, BBUCKLEY@POST.ROYALROADS.CA]

June 10–11: Kananaskis Village, Alberta. 3rd Western Canada Linear Algebra Meeting. The Kananaskis Inn. [Doug Farenick, farenick@abel.math.uregina.ca: Dept. of Mathematics & Statistics, University of Regina, Regina, Saskatchewan S4S 0A2] *See Image 16:8.*

June 12–15: Newport, Rhode Island. ATLAST Workshop. Salve Regina University. [Steven J. Leon, Dept. of Mathematics, University of Massachusetts–Dartmouth, Old Westport Road, North Dartmouth, MA 02747-2300; FAX (1-508) 999-8901, SLEON@UMASSD.EDU, http://tango.mth.umassd.edu/ATLAST/ATLAST.html] *See Image 16:9.*

June 17–20: Baltimore, Maryland. 8th SIAM Conference on Discrete Mathematics. Johns Hopkins University. [SIAM, 3600 Univ. City Science Center, Philadelphia, PA 19104-2688; FAX (1-215) 386-7999, http://www.siam.org, MEETINGS@SIAM.ORG]

June 17–21: Pontresina, Switzerland. 13th Householder Symposium on Numerical Algebra. Hotel Kronenhof. [Dianne P. O'Leary, Chair: Program Committee; OLEARY@CS.UMD.EDU, http://www.cs.umd.edu/users/oleary] *See Image 16:10.*

June 20–21: Belgrade, Serbia-Yugoslavia. Dragoslav S. Mitrinovic; (1908–1995) Memorial Conference. Serbian Scientific Society. [Gradimir V. Milovanovic;, Faculty of Electronic Engineering, P. O. Box 73, 18000 Niš, Serbia-Yugoslavia; MILOVANOVIC@IPRVS1.UNIV-PAU.FR]

June 23–July 6: Gran Canaria, Canary Islands. NATO Advanced Study Institute on Algorithms for Solving Large Linear Systems & Applications. [Gabriel Winter, CEANI, Universidad de Gran Canaria, Tafira Alta, Gran Canaria; FAX (34-28) 451916, MANOLO@ARIES.DMA.ULPGC.ES]

June 24–27: Russe, Bulgaria. 1st Workshop on Numerical Analysis & Applications. [Marcin Paprzycki, Dept. of Mathematics & Computer Science, Univ. of Texas–Permian Basin, Odessa, TX 79762; paprzycki_m@gusher.pb.utexas.edu] *See Image 16:10.*

June 24–28: St. Louis, Missouri. International Symposium on the Mathematical Theory of Networks and Systems. Washington University. [Biswa Nath Datta, Dept of Mathematical Sciences, Northern Illinois University, DeKalb, IL 60115; FAX (1-815) 753-1112, DATTAB@MATH.NIU.EDU]

July 7–12: Sydney, Australia. Sydney International Statistical Congress: SISC-96. IMS Special Topics Meeting: Contemporary Nonparametrics; 13th Australian Statistical Conference: Quality & Environment; Computer Science & Statistics: 28th Symposium on the Interface. Sheraton-Wentworth Hotel. [John Mulready, Conference Action Pty Ltd, PO Box 1231, North Sydney, NSW 2059; SYDNEY96@SYD.DMS.CSIRO.AU, FAX (61-2) 956-5154]

July 8–12: Prague, Czech Republic. Prague Mathematical Conference in Honor of the 70th Birthdays of Ivo Babuška & Miroslav Fiedler, Jaroslav Kurzweil & Vlastimil Pták. Pyramida Hotel. [Mathematical Institute, Academy of Sciences, Žitná 5, CZ-115 67 Praha 1; FAX (422-2) 422-7633, PMC96@EARN.CVUT.CZ]

July 18–19: Shrewsbury, England. 5th International Workshop on Matrix Methods for Statistics. Gateway Centre for Education and Art. [R William Farebrother, 11 Castle Road, Bayston Hill, Shrewsbury SY3 0NF; FAX (441-61) 275-4812, r.w.farebrother@man.ac.uk] *See Image 16:11.*

July 24–27: La Jolla, California. ATLAST Workshop. University of California–San Diego. [Steven J. Leon, Dept. of Mathematics, University of Massachusetts–Dartmouth, Old Westport Road, North Dartmouth, MA 02747-2300; FAX (1-508) 999-8901, SLEON@UMASSD.EDU, http://tango.mth.umassd.edu/ATLAST/ATLAST.html] *See Image 16:9.*

July 27–30: Cambridge, England. Conference on Numerical Mathematics Celebrating the 60th Birthday of M. J. D. Powell. [MD Buhmann, Mathematics Dept, ETH Zentrum, CH-8092 Zürich; MDB@MATH.ETHZ.CH]

August 6–9: Sapporo, Japan. 3rd Workshop on Numerical Ranges & Numerical Radii. The Sapporo Guest House. [T Ando, Faculty of Economics, Hokusei Gakuen University, Atsubetsu-ku, Sapporo 004] *See Image 14:42.*

August 12–16: Jilin, China. 2nd China Matrix Theory Conference. Chinese Mathematical Society & Jilin Normal College. [Bit-Shun Tam, Dept of Mathematics, Tamkang University, Tamsui 25137, Taiwan; BSM01@HPAP.TKU.EDU.TW, FAX (886-2) 620-9916] *See Image 15:16.*

August 14–17: Chemnitz, Germany. International Linear Algebra Society (ILAS) Conference. [VL Mehrmann, Fakultät für Mathematik, Technische Universität Chemnitz-Zwickau, PSF 964, D-09009 Chemnitz; FAX (49-371) 531-2657, MEHRMANN@MATHEMATIK.TU-CHEMNITZ.DE, http://www.tu-chemnitz.de/ilas/] *See Image 16:12.*

August 21–24: Leuven, Belgium. 2nd International Workshop on Total Least Squares and Errors-in-Variables Modeling. [Ida Tassens Dept. of Electrical Engineering, ESAT/SISTA, Katholieke Universiteit Leuven, Kardinaal Mercierlaan 94, B-3001 Leuven-Heverlee; ida.tassens@esat.kuleuven.ac.be, FAX (32-16) 32.19.86] *See Image 16:12.*

August 26–29: Beijing, China. 3rd Gauss Symposium. [WA Rodrigues Jr., Division of Math & Theoretical Physics, Institutum Gaussianum, IMECC-UNICAMP, CP 6065, 13081-970 Campinas SP; WALROD@IME.UNICAMP.BR]

October 9–11: Cœur d'Alene, Idaho. 2nd SIAM Conference on Sparse Matrices. Cœur d'Alene Resort. [SIAM, 3600 University City Science Center, Philadelphia, PA 19104-2688; http://www.siam.org, MEETINGS@SIAM.ORG, FAX (1-215) 386-7999] *See Image 16:13.*

1997

January 10–13: San Diego, California. Joint Mathematics Meetings: American Mathematical Society (AMS) & Mathematical Association of America (MAA). [MEET@MATH.AMS.ORG: H Daly, AMS, PO Box 6887, Providence, RI 02904-6887]

June 6–8: Winnipeg, Manitoba. International Linear Algebra Society (ILAS) Symposium: Fast Algorithms for Control, Signals and Image Processing. [Robert J Plemmons, Computer Science Dept., Box 7388, Wake Forest University, Winston-Salem, NC 27109; plemmons@mthcsc.wfu.edu] *See Image 16:13.*

1998

January 10–13: Baltimore, Maryland. Joint Mathematics Meetings: American Mathematical Society (AMS) & Mathematical Association of America (MAA). [MEET@MATH.AMS.ORG; H Daly, AMS, PO Box 6887, Providence, RI 02904-6887]

June 3–6: Madison, Wisconsin. International Linear Algebra Society (ILAS) Conference. [Richard A Brualdi, Dept of Mathematics, Univ of Wisconsin, Van Vleck Hall, 480 Lincoln Drive, Madison, WI 53706-1388; FAX (1-608) 262-1402, BRUALDI@MATH.WISC.EDU]

2002

Auburn, Alabama. International Linear Algebra Society Conference: Challenges. [Frank Uhlig, Dept. of Mathematics, Auburn University, Alabama, AL 36849-5310; uhligfd@mail.auburn.edu] *See Image 16:28.*

5th ILAS Conference: Atlanta, Georgia, August 16–19, 1995

5th ILAS Conference: Atlanta, Georgia, August 16-19, 1995

New and Forthcoming Publications in Linear Algebra

Paul R. Halmos: *Linear Algebra Problem Book*

Reviewed by S. W. Drury, McGill University, Montréal

Linear Algebra Problem Book by Paul R. Halmos [Dolciani Mathematical Expositions, 16, Mathematical Association of America, Washington, DC, xiv + 336 pp., ISBN 0-88385-322-1 (P), US$35.00] is written as a supplement to the author's *Finite-Dimensional Vector Spaces* [Second Edition. Springer-Verlag, 1974] very much in the style of his *A Hilbert Space Problem Book* [Second Edition, Springer-Verlag, 1982]. Looking back on my mathematical education, I realize how much I owe to Halmos for writing these two books.

The *Linear Algebra Problem Book* is organized like the Hilbert Space one. About half the book describes the problems. There follows a very short section that provides a hint for each problem. In the final section detailed solutions are given. It is important to have a basic working knowledge of the subject matter before delving into the problems. Halmos has a knack of choosing problems that develop one's understanding of the field. They vary in difficulty from the very easy to the brain-jammer that will confound even the expert for more than the two minutes suggested in the preface. As in *A Hilbert Space Problem Book*, the style is casual and friendly.

The topics covered are Scalars, Vectors, Bases, Transformations, Duality, Similarity, Canonical Forms, Inner Product Spaces and Normality. Some readers will find the early questions on nonstandard operations quite tedious, but it is only through a recognition of what can go wrong that we come to understand the usual manipulations of linear algebra. In fact, it is because of Halmos's meticulous understanding of the way that the subject is constructed that he is able to find such unusual and instructive problems. Halmos excels at interpreting abstract mathematics, and one feels that he was wise not to include problems relating to areas of matrix theory that do not have underpinnings in mainstream linear algebra. Nevertheless, many will lament that topics in multilinear algebra such as tensor, symmetric and exterior products are not treated.

On the whole the book is well produced, but there are some lapses, the glaringly tautological Problem 139, for example. The book could be used by undergraduates as a supplementary text in an abstract linear algebra course, but it is really a book for self study and will also appeal to graduate students.

New Book Announcements

Richard A. Brualdi and Bryan L. Shader: *Matrices of Sign-solvable Linear Systems*

Matrices of Sign-solvable Linear Systems by Richard A. Brualdi and Bryan L. Shader [Cambridge Tracts in Mathematics, 116, Cambridge University Press, 1995, xii + 298 pp., ISBN 0-521-48296-8 (H)] is listed at US$49.95 but is currently offered by the publisher at US$39.96 (a 20% discount).

The sign-solvability of a linear system implies that the signs of the entries of the solution (or at least some of the entries) are determined solely on the basis of the signs of the coefficients of the system. That it might be worthwhile and possible to investigate such linear systems was recognized by Paul Samuelson in his classic book *Foundations of Economic Analysis.* Sign-solvability is part of a larger study which seeks to study and understand the special circumstances under which an algebraic, analytic or geometric property of a matrix can be determined from the combinatorial arrangement of the positive, negative and zero elements of the matrix. These are thus properties shared by all members of a qualitative class of matrices. Several classes of matrices arise in this way, notably sign-nonsingular matrices, L-matrices, S-matrices, and sign-stable matrices. The essential idea of a sign-nonsingular matrix arose in a different context in the key 1963 paper "Dimer statistics and place transitions" by P. W. Kastelyn. The large and diffuse body of literature connected with sign-solvability is presented as a coherent whole for the first time in this book. Results in the literature are presented in a new and organized way with many new connections established and with many new results and proofs. One of the features of this book is that algorithms that are implicit in many of the proofs have been explicitly described and their complexity has been commented on.

The book is intended primarily for researchers in combinatorics and linear algebra but it should be of interest to theoretical computer scientists, economists, physicists, chemists, engineers and other scientists. It should also be of interest to those who would like to see the beautiful interplay that it affords between combinatorics (especially, graph theory) and linear al-

gebra. The book is self-contained but it does assume that the reader is familiar with elementary linear algebra and has been introduced to some aspects of graph theory and combinatorial matrix theory.

Biswa Nath Datta: *Numerical Linear Algebra and Applications*

Numerical Linear Algebra and Applications by Biswa Nath Datta [Brooks/Cole, Pacific Grove, CA, 1995, xxii + 680 pp., ISBN 0-534-17466-3 (H), US$58.75] can be used in both undergraduate and beginning level graduate courses on Numerical Linear Algebra, Numerical Analysis, and Applied Linear Algebra, in Mathematics, Statistics, Computer Science, and Engineering. It should also be useful for self-study and reference work by scientists and engineers. Starting from basic concepts and gradually leading to more advanced and up-to-date topics, the book gives thorough coverage of the main topics of Numerical Linear Algebra: Numerical Solutions of Linear Systems, Least Squares Problems, Eigenvalue and Generalized Eigenvalue Problems, and Singular Value Decomposition.

A major strength of the book is a rich set of applications. To motivate the students to learn numerical linear algebra, I have taken a special care to connect Numerical Linear Algebra to applied areas such as Engineering (e.g., Heat Transfer, Fluid Dynamics, Chemical Plants, Electrical Networks, Vibration of Structures, etc.), Physics, Chemistry, Statistics, Control Theory, Signal Processing, and Bio-medical Engineering, etc. In every chapter after a physical problem has been posed, I have explained the physical and engineering significance of its solution. Real-life case studies of major problems have been included. The book contains far more material than can be covered in one semester, so teachers can tailor material to particular classes and easily develop course syllabi. The book has been class-tested by me and other colleagues.

Israel Gohberg, Marinus A. Kaashoek, and Frederik van Schagen: *Partially Specified Matrices and Operators: Classification, Completion, Applications*

Partially Specified Matrices and Operators: Classification, Completion, Applications by Israel Gohberg, Marinus A. Kaashoek, Frederik van Schagen [Operator Theory Advances and Applications, vol. 79, Birkhäuser Verlag, Boston, 1995, xi + 333 pp., ISBN 3-7643-5259-0 (H), US$139.00] is devoted to the new direction in linear algebra and operator theory that deals with the invariants of partially specified matrices and operators, and with the spectral analysis of their completions. The theory developed centers around two major problems concerning matrices of which part of the entries are given and the others are unspecified. The first is a problem of classification of partially specified matrices, and the results here may be seen as a far reaching generalization of the Jordan canonical form. The second problem is the eigenvalue completion problem, which asks for a description of all possible eigenvalues and their multiplicities of the matrices which one obtains by filling in the unspecified entries. Both problems are also considered in an infinite dimensional framework. A large part of the book deals with applications to matrix theory and analysis, namely to stabilization problems in mathematical system theory, to problems of Wiener-Hopf factorization and interpolation for matrix polynomials and rational matrix functions, to the Kronecker structure theory of linear pencils, and to non-everywhere defined operators. The book will appeal to a wide group of mathematicians and engineers. Much of the material can be used in advanced courses in matrix and operator theory.

Peter Lancaster and Leiba Rodman: *Algebraic Riccati Equations*

Algebraic Riccati Equations by Peter Lancaster and Leiba Rodman [Oxford University Press, 1995, xvii + 480 pp., ISBN 0-19-853795-6 (H), US$115.00, C$175.00, UK£65.00] is the first book to cover this area of increasing interest. Applications are discussed. This book provides a careful treatment of the theory of algebraic Riccati equations. It consists of four parts: the first part is a comprehensive account of necessary background material in matrix theory including careful accounts of recent developments involving indefinite scalar products and rational matrix functions. The second and third parts form the core of the book and concern the solutions of algebraic Riccati equations arising from continuous and discrete systems. The geometric theory and iterative analysis are both developed in detail. The last part of the book is an exciting collection of eight problem areas in which algebraic Riccati equations play a crucial role. These applications range from introductions to the classical linear quadratic regulator problems and the discrete Kalman filter to modern developments in H-infinity control and total least squares methods.

Contents: Part I: Matrix Theory. Preliminaries from the theory of matrices; Indefinite scalar products; Skew-symmetric scalar products; Matrix theory and control; Linear matrix equations; Rational matrix functions. Part II: Continuous Alge-

braic Riccati Equations. Geometric theory: the complex case; Geometric theory: the real case; Constructive existence and comparison theorems; Hermitian solutions and factorizations of rational matrix functions; Perturbation theory. Part III: Discrete Algebraic Riccati Equations. Geometric theory; Constructive existence and comparison theorems; Perturbation theory; Discrete algebraic Riccati equations and matrix pencils. Part IV: Applications and Connections.. Linear-quadratic regulator problems; The discrete Kalman filter; The total least squares technique; Canonical factorization; H-infinity control problems; Contractive rational matrix functions; The matrix sign function; Structured stability radius. Bibliography; List of notations; Index.

M. Moonen and Bart de Moor, eds.: *SVD and Signal Processing III, Algorithms, Architectures and Applications*

SVD and Signal Processing III, Algorithms, Architectures and Applications edited by M. Moonen and Bart De Moor [Proceedings of the 3rd International Workshop, Leuven, Belgium, 22–25 August 1994, Elsevier Science, 498 pp., ISBN 0-444-82107-4 (H), US$191.25] explores the Matrix Singular Value Decomposition (SVD) and its application to problems in signal processing is explored in this book. The papers discuss algorithms and implementation architectures for computing the SVD, as well as a variety of applications such as systems and signal modeling and detection. The publication presents a number of keynote papers, highlighting recent developments in the field, namely large scale SVD applications, isospectral matrix flows, Riemannian SVD and consistent signal reconstruction. It also features a translation of a historical paper by Eugenio Beltrami, containing one of the earliest published discussions of the SVD. With contributions sourced from internationally recognized scientists, the book will be of specific interest to all researchers and students involved in the SVD and signal processing field.

More Books on Linear Algebra and Related Topics: 1995–1996

by Simo Puntanen, *University of Tampere* & George P. H. Styan, *McGill University*

Listed below are some more books on linear algebra and related topics that have been published in 1995 or in 1996; this list augments and updates the lists published in *Image* 14:23–26; 15:8–9. References to reviews in *Mathematical Reviews* [MR] are given in square brackets; (P) denotes paperback and (H) hard cover.

Aitken, A. C. (1995). *To Catch the Spirit: The Memoir of A. C. Aitken.* With a Biographical Introduction by P. C. Fenton. University of Otago Press, 123 pp., ISBN 0-908569-99-8 (P).

Axler, Sheldon (1995). *Linear Algebra Done Right.* Springer-Verlag, 238 pp., ISBN 0-387-94595-4 (H), ISBN 0-387-94596-2 (P).

Björck, Åke (1996). *Numerical Methods for Least Squares Problems.* SIAM, ca. 400 pp., ISBN 0-89871-360-9 (P).

Borwein, Peter & Erdélyi, Tamás (1995). *Polynomials and Polynomial Inequalities.* Graduate Texts in Mathematics, 161. Springer-Verlag, x + 480 pp. ISBN 0-387-94509-1.

Bronson, Richard (1995). *Linear Algebra: An Introduction.* Academic Press, 504 pp., ISBN 0-12-135245-5 (P).

Bugl, Paul (1995). *Differential Equations: Matrices and Models.* Prentice Hall, xvi + 669 pp., ISBN 0-02-316540-5.

Corwin, Lawrence J. & Szczarba, Robert H. (1995). *Calculus in Vector Spaces.* Second Edition. Monographs and Textbooks in Pure and Applied Mathematics, 189. Marcel Dekker, xiv + 583 pp., ISBN 0-8247-9279-3 (H).

Edwards, Harold M. (1995). *Linear Algebra.* Birkhäuser, xiv + 184 pp., ISBN 0-8176-3731-1 (H).

Gajić, Zoran & Qureshi, Muhammad Tahir Javed (1995). *Lyapunov Matrix Equation in System Stability and Control.* Mathematics in Science & Engineering, 195. Academic Press, xii + 255 pp., ISBN 0-12-273370-3 (H).

Golan, Jonathan S. (1995). *Foundations of Linear Algebra.* Kluwer Texts in the Mathematical Sciences, 11. Kluwer, viii + 236 pp., ISBN 0-7923-3614-3 (H). [Translated by the author from the 1992 Hebrew original.]

Hadi, Ali S. (1996). *Matrix Algebra as a Tool,* Duxbury Press/Wadsworth, xi + 212 pp., ISBN 0-534-23712-6 (P).

Hart, George W. (1995). *Multidimensional Analysis.* Springer-Verlag, xii + 236 pp., ISBN 0-387-94417-6.

Higham, Nicholas J. (1996). *Accuracy and Stability of Numerical Algorithms.* SIAM, xxviii + 688 pp., ISBN 0-89871-355-2 (P).

Hill, Richard O., Jr. (1996). *Elementary Linear Algebra with Applications*. Third Edition. Saunders College, xvii + 516 pp., ISBN 0-03-010347-9.

Jacob, Bill (1995). *Linear Functions and Matrix Theory: An Introduction*. Springer-Verlag, x + 330 pp., ISBN 0-387-94451-6 (P).

Kato, Tosio (1995). *Perturbation Theory for Linear Operators*. Second Edition. Springer-Verlag, xxi + 619 pp., ISBN 3-540-58661-x (P).

Kostrikin, Alexei I. (1996). *Exercises in Algebra: A Collection of Exercises in Algebra, Linear Algebra and Geometry*. Gordon and Breach, 480 pp., ISBN 2-88449-029-9 (H), ISBN 2-88449-030-2 (P).

Lancaster, Peter & Rodman, Leiba (1995). *Algebraic Riccati Equations*. Oxford University Press, xviii + 480 pp., ISBN 0-19-853795-6 (H).

Liu, Shuangzhe (1995). *Contributions to Matrix Calculus and Applications in Econometrics*. Tinbergen Institute Research Series, 106. Thesis Publishers, Amsterdam, xii + 121 pp., ISBN 90-5170-356-2 (P).

Marchand, Patrick (1996). *Graphics and GUIs with* MATLAB. CRC Press, vi + 365 pp. & 3.5" PC diskette, ISBN 0-8493-9487-2 (P). [GUI = Graphical User Interface.]

Meyer, Carl D., Jr. *Matrix Analysis and Applied Linear Algebra*. Under development, ca. 600 pp. [Draft copies available from Sir Speedy, 2526 Hillsborough Street, Suite 102, Raleigh, NC 27607.]

Porter, Gerald & Hill, David (1996). *Interactive Linear Algebra Using* MATHCAD®. Springer-Verlag, in press, ISBN 0-387-94608-X (P).

Rao, C. Radhakrishna, and Toutenburg, Helge (1995). *Linear Models: Least Squares and Alternatives*. Springer-Verlag, xi + 352 pp., ISBN 0-387-94562-8 (H).

Robbin, Joel W. (1995). *Matrix Algebra: Using MINImal MATlab*. AK Peters, xvi + 544 pp. & 3.5" PC diskette, ISBN 1-56881-024-5 (H).

Rotella, Frédéric & Borne, Pierre (1995). *Théorie et pratique du calcul matriciel*. Méthodes et Pratiques de l'Ingénieur, 6. Éditions Technip, Paris, 339 pp. ISBN 2-7108-0675-4.

Saad, Yousef (1996). *Iterative Methods for Sparse Linear Systems*. PWS, xvi + 447 pp., ISBN 0-534-94776-X (H).

Schay, Geza (1996). *Linear Algebra*. Jones & Bartlett, 280 pp., ISBN 0-86720-518-0 (H).

Stewart, G. W. (1996). *Afternotes on Numerical Analysis*. SIAM, x + 200 pp., ISBN 0-89871-362-5 (P). [Series of 22 lectures on elementary numerical analysis.]

Stroth, Gernot (1995). *Lineare Algebra*. Berliner Studienreihe zur Mathematik, 7. Heldermann Verlag, Lemgo, viii + 384 pp., ISBN 3-88538-107-9.

Tiit, E.-M; Kollo, T. & Niemi, H., eds. (1995). *Multivariate Statistics and Matrices in Statistics*. New Trends in Probability and Statistics, 3. TEV, Vilnius & VSP, Utrecht, x + 342 pp., ISBN 90-6764-195-2 (H). [Proceedings of the 5th Tartu Conference, Tartu-Pühajärve, Estonia, 23–28 May 1994.]

White, Neil L., ed. (1995). *Invariant Methods in Discrete and Computational Geometry*. Kluwer, xiv + 328 pp., ISBN 0-7923-3548-1. [Proceedings of the Conference Held in Curaçao, June 13–17, 1994.]

Linear Algebra and Its Applications—Forthcoming Special Issues

Proceedings of the Fourth Conference of the International Linear Algebra Society (Rotterdam, The Netherlands, August 1994). Special Editors: Harm Bart, Ludwig Elsner & Andre Ran.

Proceedings of the Fifth Conference of the International Linear Algebra Society (Atlanta, Georgia, August 1995). Special Editors: Frank J. Hall, Alex Pothen, Frank Uhlig & Paul M Van Dooren.

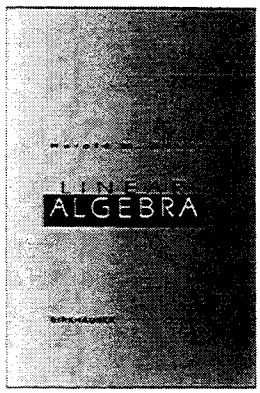
Proceedings of the Sixth Conference of the International Linear Algebra Society (Chemnitz, Germany, August 1996). Special Editors: Steve Kirkland, Volker Mehrmann, Gerhard Michler & Bryan L. Shader.

Sixth Special Issue on Linear Algebra and Statistics. Special Editors: R. William Farebrother, Simo Puntanen, George P. H. Styan & Hans Joachim Werner. [Will include papers presented at the Fourth International Workshop on Matrix Methods for Statistics, Montréal, Québec, Canada, July 1995.]

A Guide to Books on Matrices and Books on Inequalities, with Statistical and Other Applications by George P. H. Styan & Simo Puntanen.

LINEAR ALGEBRA

Harold M. Edwards, *New York University*



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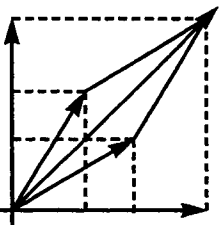
Matrix Algebra *Using MINImal MATlab*



Joel W. Robbin

Robbin has created the ultimate student-friendly book on the subject of matrix algebra. This undergraduate text aims to teach mathematical literacy by providing a careful treatment of set theoretic notions and elementary mathematical proofs. It gives a complete handling of the fundamental normal form theorems of matrix algebra. Use of the computer is fully integrated into Robbin's approach; not only does the book describe the basic algorithms in the computer language MATlab and provide unique computer exercises, it also includes as a part of the complete whole an accompanying diskette and tutorial manual. This text takes the teaching of matrix algebra to the heights of modern instructional techniques and would be the essential foundation to any course on the subject.

Contents

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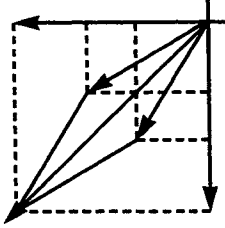

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Numerical Methods for Least Squares Problems

Åke Björck

The method of least squares was discovered by Gauss in 1795. It has since become the principal tool to reduce the influence of errors when fitting models to given observations. Today, applications of least squares arise in a great number of scientific areas, such as statistics, geodetics, signal processing, and control. Until now there has not been a monograph that covers the full spectrum of relevant problems and methods in least squares.

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"Challenges" in Matrix Theory

During our life and work as research mathematicians, we generally write a number of technical and conceptual papers. Yet in our work we often touch on the unknown and mysterious, mathematically mysterious, that we—individually and in groups of collaborators alike—do not seem to be able to readily understand. Anyone formulating a "Challenge" proposal should attempt to discuss such a problem with its history, ramifications and consequences to the field or subfields of Linear Algebra or to its applications. A "Challenge" is not a list of 'open problems', nor is it a list of Ph. D. thesis topics. It is rather meant to address more profound and deeper levels of our field.

Examples: In Calculus, the trigonometric functions can be defined geometrically as ratios of lengths of sides. "Challenge": Find a solely geometric proof (i.e., one using only slopes of their graphs for example, but no limits, etc.) to obtain/prove their differential relations. [Solved: see e.g., *Mitteilungen Math. Sem. Giessen,* 173 (1986):36–41.]

Or Find (possibly graph-theoretic) methods that improve the conditioning of linear equations elimination schemes as work progresses. [Unsolved.]

Or Find a general matrix analogue for the Perron–Frobenius theory of positive matrices. (Partially solved by S. Rump, 1995 via his real spectral radius concept.)

Or The challenge by Gilbert Strang at his after-dinner speech at ILAS 95 in Atlanta regarding conditions for the solvability of simultaneous quadratic equations. [Unsolved.]

Ideally, a "Challenge" should describe a mathematical problem at the current limits of understanding and research, a problem that the proposer feels/proposers feel would be important to know the answer to, but for which he/she sees no means to a solution in the near future within his/her research group.

"Challenges" should be well documented and clearly described on 2–5 pages (exceptions possible) with an attempt at a complete list of the relevant literature, all known avenues to the problem and a detailed statement of the relevance of the topic. Each "Challenge" should be submitted to Frank Uhlig, Coordinator of the "Challenges" Advisory Panel (CAP), by the deadline of January 15, 1997.

In order to help the refereeing process, which shall be done in a cooperative effort involving the whole linear algebra community, we welcome a short list of potential referees whom the submitter considers to be experts in the area. Each CAP member will strive to enhance the presentation of the "Challenges" during the refereeing process.

Early submissions and tentative early drafts are welcome for pre-review. In each instance, the final draft of a "Challenge" must be received by the deadline and all submissions will be judged by the standard rules and criteria that apply to *Linear Algebra and Its Applications* (LAA). If a sufficiently many "Challenges" are received, the LAA Editors-in-Chief have agreed to publish the "Challenges" a special section of LAA, quickly in early 1998, once the overall refereeing process has been completed in order to allow for ample time for solutions (1998 → 2001), and the selection of solutions to be presented as part of the n^{th} ILAS Conference at Auburn University in 2002.

"Challenges" may address any and all areas of Linear Algebra and Matrix Theory as well as applications; i.e., they may be from core or numerical linear algebra, graph-theoretic or control-theoretic matrix theory, or from signals, or whatever, as long as the subject is matrix theoretical.

All "Challenges" should include a detailed account of the history, notations, references and an explanation of the significance and envisioned uses of the proposed "Challenge" problem. Each submission should be accompanied by the name(s) of the member(s) of the advisory panel who—in the eyes of the submitter(s)—would be most knowledgeable and helpful in handling the specific "Challenge". In order to speed up the refereeing process and to keep within the deadlines, we encourage submitting an additional list of potential referees for each problem. The task of the "Challenges" Advisory Panel and the chosen referees is to try to scrutinize the status of the problem and if deemed open and significant to try to enhance its presentation as much as possible. The refereeing process for the "Challenges" shall be performed on a cooperative basis involving all of us to obtain a truly valuable collection of significant "Challenge" problems in Linear Algebra.

Electronic submission in TEX or LATEX format is preferred. For easy transportability of the files amongst the reviewers, however, we ask all submitters to try and refrain from using extensive macros.

"Challenges" Coordinator: Frank Uhlig
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Hüseyin Tevfik Paşa: 1832–1901

In the last issue of *Image* [no. 15, page 24] we challenged readers to identify a certain gentleman and asked "Is his book on Linear Algeba, published in 1882, the first book ever published on Linear Algebra?"

We are very grateful to Fikri Akdeniz (Çukurova University, Adana, Turkey) for drawing to our attention the book entitled "Linear Algebra (in English) by Hüseyin Tevfik Paşa (1832–1901) published by the "Press of A. H. Boyajian (69 pp.) in Constantinople (now Istanbul) in 1882. A copy of the original book is in the Harvard University Library and bound within the frontal matter is an original letter dated February 5th, 1885, from, and signed by, Hüseyin Tevfik to Justin Winsor, Esq., Librarian of the Harvard College Library, bequeathing the book at "the request of the distinguished professor J. M. Peirce of the Department of Mathematics in the Harvard College." A "Second Edition: Revised and Enlarged" was published in 1892 (again by Boyajian in Constantinople). A paperback reprint of both the original version (1882) and the Second Edition (1892), bound together as one volume, was published by the Istanbul Technical University [Bilim ve Teknoloji Tarihi Araştırma Merkezi Yayın, no. 5] in 1988. This reprint was edited by Kâzım Çeçen and includes a preface by Ilhan Kayan, introduction by Kâzım Çeçen and a "contemporary assessment" by Cahit Arf (in Turkish and in English) and a biography (in Turkish) of Hüseyin Tevfik Paşa by A. M. C. Şengör.

We are also very grateful to Garry J. Tee (University of Auckland, Auckland, New Zealand) for drawing our attention to the book entitled "Linear Associative Algebra" by Benjamin Peirce (1809–1880). A copy of the original version published in "Washington City," (153 pp.) in 1870 is in the University of California–Berkeley Library and includes a "Sketch of Professor Benjamin Peirce" and portrait inserted (from *Popular Science Monthly,* March 1881). Another copy (on microfilm, 1 reel, 35 mm, 1983) is in the Preservation Office Microfilming Unit, University of Michigan Library, Ann Arbor. A "New Edition, with Addenda and Notes, by C. S. Peirce, Son of the Author" was published (posthumously) by D. Van Nostrand (133 pp.) in New York in 1882 (and reprinted in "Benjamin Peirce: "Father of Pure Mathematics" in America" edited by I. Bernard Cohen [Arno Press, New York, 1980]). This 1882 edition is based on the version published in the *American Journal of Mathematics* 4 (1881):97–229.

Some Early Contributions to 2×2 Matrix Algebra

The formal origin of matrix algebra is usually traced to the work of Cayley and Sylvester in the middle of the nineteenth century. But, with the aid of *Geometry and Algebra in Ancient Civilizations* by B. L. van der Waerden (Springer-Verlag, 1983), we may now show that several elements of this theory are of a much earlier date. On pages 134-135 of this book van der Waerden notes that the fifth century Greek mathematician Proklos (or Proclus) had defined an iterative process which we would write as

$$\begin{aligned} x_{n+1} &= x_n + 2y_n \\ y_{n+1} &= x_n + y_n \end{aligned}$$

for obtaining successively closer approximations to the square root of two. For example, from the starting values $x_1 = y_1 = 1$ we have the ratios $x_2/y_2 = 3/2$, $x_3/y_3 = 7/5$, and so on.

Defining the matrices

$$A(d) = \begin{pmatrix} 1 & d \\ 1 & 1 \end{pmatrix} \qquad B(d) = \begin{pmatrix} d & 1 \\ 1 & 0 \end{pmatrix}$$

where d is a positive integer, we immediately deduce that this iterative process is an instance of the familiar power method for determining the characteristic vector $(\sqrt{2}, 1)'$ corresponding to the largest characteristic value of $A(2)$.

Now $A(2)$ is related to $B(2)$ by the similarity transformation

$$\begin{pmatrix} 1 & 1 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 2 \\ 1 & 1 \end{pmatrix} \begin{pmatrix} 1 & -1 \\ 0 & 1 \end{pmatrix} = \begin{pmatrix} 2 & 1 \\ 1 & 0 \end{pmatrix}$$

so that $B(2)$ has the same characteristic values as $A(2)$ and dominant characteristic vector $(1 + \sqrt{2}, 1)'$, so that the process

$$\begin{aligned} u_{n+1} &= 2u_n + v_n \\ v_{n+1} &= u_n \end{aligned}$$

or, equivalently,

$$u_{n+1} = 2u_n + u_{n-1}$$

defines a sequence of ratios giving ever closer approximations to $1 + \sqrt{2}$.

An explicit expression for this ratio may be obtained by rewriting this equation as

$$w_{n+1} = 2 + \frac{1}{w_n}$$

where

$$w_{n+1} = \frac{u_{n+1}}{u_n}.$$

Repeated substitution reveals that the solution may be written in the form of a continued fraction

$$w_{n+1} = (2 + 1/)(2 + 1/) \ldots (2 + 1/)w_1$$

or, more conventionally, as

$$w_{n+1} = 2 + \cfrac{1}{2 + \cfrac{1}{2 + \cdots \cfrac{1}{w_1}}}$$

Proklos's iterative procedure for evaluating the square root of two may readily be generalised to the square root of any integer $d \geq 2$.

$$x_{n+1} = x_n + dy_n y_{n+1} = x_n + y_n$$

But the corresponding generalisation of the continued fraction expansion is less immediate as we have to identify a sequence of matrices of type B whose product is similar to $A(d) + kI$ where I is the 2×2 identity matrix and k is some suitable nonnegative multiplier. For example, when $d = 3$ we set $k = 1$ and find that the product

$$\begin{pmatrix} 1 & 1 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} 2 & 3 \\ 1 & 2 \end{pmatrix} \begin{pmatrix} 1 & -1 \\ 0 & 1 \end{pmatrix} = \begin{pmatrix} 3 & 2 \\ 1 & 1 \end{pmatrix}$$

may also be expressed in the form

$$\begin{pmatrix} 3 & 2 \\ 1 & 1 \end{pmatrix} = \begin{pmatrix} 2 & 1 \\ 1 & 0 \end{pmatrix} \begin{pmatrix} 1 & 1 \\ 1 & 0 \end{pmatrix}$$

so that $w = \sqrt{3} + 1$ (which satisfies $w/1 = (3w + 2)/(w + 1)$) has the continued fraction expansion

$$2 + \cfrac{1}{1 + \cfrac{1}{2 + \cfrac{1}{1 + \cfrac{1}{2 \cdots}}}}$$

In conclusion we note that the arithmetic of matrices of the form

$$\begin{pmatrix} a & db \\ b & a \end{pmatrix}$$

is isomorphic to the arithmetic of numbers of the form

$$a + b\sqrt{d}$$

when a, b and d are integers and d is not a square.

In particular we have

$$\begin{pmatrix} a & -db \\ -b & a \end{pmatrix} \begin{pmatrix} a & db \\ b & a \end{pmatrix} = (a^2 - db^2) \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$$

which may be rewritten as the relationship

$$\begin{pmatrix} a & b \\ db & a \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 0 & -d \end{pmatrix} \begin{pmatrix} a & db \\ b & a \end{pmatrix} = (a^2 - db^2) \begin{pmatrix} 1 & 0 \\ 0 & -d \end{pmatrix}$$

that forms the basis of much of the early work on the solution of Pell's equation

$$x^2 - dy^2 = +1$$

in integers. See van der Waerden (op. cit., pp.134–154) for details.

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IMAGE Problem Corner

We invite readers to submit solutions to the following problems, as well as new problems, for publication in *Image*. Please send material to George P. H. Styan, Joint Editor: *Image*, preferably in LaTeX and by e-mail to `styan@math.mcgill.ca`.

Problem 16-1: A Determinantal Inequality.
Proposed by FUZHEN ZHANG, *Nova Southeastern University, Ft. Lauderdale, FL, USA.*

Show that for any square complex matrices X and Y of the same size

$$|\det(X+Y)|^2 \le \det(I+XX^*)\det(I+Y^*Y),$$

where $*$ means conjugate transpose.

Problem 16-2: A Hadamard Product Inequality.
Proposed by FUZHEN ZHANG, *Nova Southeastern University, Ft. Lauderdale, FL, USA.*

Let A be an $n \times n$ complex matrix, and let U be an $n \times n$ unitary matrix. Denote the Hadamard product of A and U by $A \circ U = (a_{ij}u_{ij})$, and the largest singular value by $\sigma_{\max}$. Then show that

$$\min_U \sigma_{\max}(A \circ U) \le \frac{1}{\sqrt{n}} \left(\sum_{i,j=1}^{n} |a_{ij}|^2 \right)^{\frac{1}{2}}.$$

Problem 16-3: Algebraic Characterization of the Least Squares Estimator.
Proposed by R. WILLIAM FAREBROTHER, *Victoria University of Manchester, Manchester, England.*

Let X be an arbitrary $n \times p$ real matrix and let y be an arbitrary $n \times 1$ matrix. Let f be a p-element function of these matrices satisfying the linearity conditions

$$\begin{aligned} f(X, sy) &= sf(X, y) \text{ for all scalars } s \\ f(X, y + Xb) &= f(X, y) + b \text{ for all } p \times 1 \text{ matrices } b. \end{aligned}$$

Suggest additional conditions which identify this function as the least squares function

$$f(X, y) = (X'X)^{-1}X'y$$

when X has full column rank.

Problem 16-4: Reverse of a Convex Matrix Inequality.
Proposed by SHUANGZHE LIU, *University of Amsterdam, Amsterdam, The Netherlands.*

Let A and B be two positive definite matrices with eigenvalues contained in the interval $[m, M]$, where $M \ge m > 0$. Let $0 \le \lambda \le 1$. Prove that

$$\lambda A^2 + (1-\lambda)B^2 - [\lambda A + (1-\lambda)B]^2 \le \frac{1}{4}(M-m)^2 I.$$

Note that this inequality is a "reverse" of the following convex matrix inequality:

$$0 \le \lambda A^2 + (1-\lambda)B^2 - [\lambda A + (1-\lambda)B]^2.$$