Four Decades of Numerical Linear Algebra at ORNL

The "Gatlinburg" returned to Tennessee this year as part of Numerical Linear Algebra Year, which is being observed by the University of Kentucky and Oak Ridge National Laboratory from September 1, 1987, to June 30, 1988. In addition to such special events, about 40 leading researchers in numerical linear algebra and related areas of scientific computation and computer science are visiting UTK and ORNL during the special year.

The Tenth International Symposium on Numerical Algebra—Gatlinburg X—was held in Fairfield Glade during the week of October 19. Parallel numerical linear algebra and the numerical treatment of large Markov chains were the themes of the symposium, which was dedicated to the memory of the late James H. Wilkinson. Other major events scheduled for the year are workshops in each of the three major research areas in the field—systems of equations, eigenvalue problems, and least squares computations. The workshops are being held at the beginning of each quarter during the academic year at UTK.

Many visitors participated in the first workshop, held during the week of October 5, on the solution of systems of equations, the main theme of the fall quarter. The lecturers were J. Alan George, UTK-ORNL Distinguished Scientist, James Ortega from the University of Virginia, and David Young from the University of Texas. George, formerly dean of mathematics at the University of Waterloo in Ontario, Canada, joined UTK-ORNL in mid-1986. His work is mainly in sparse matrix computations and parallel computer applications. Ortega and Young focused on iterative techniques for the solution of systems of equations on vector and parallel supercomputers.

Young and two of his graduate students are spending the entire fall quarter at UTK and ORNL. George is giving a series of lectures on developed methods for sparse systems and parallel computing during the fall quarter. He is also coordinating a research seminar for the academic year.

The solution of eigenvalue and singular value problems will be the main focus of the winter quarter of 1988. The spring quarter will be devoted primarily to the solution of least squares problems.

The special year is supported by Tennessee's Science Alliance, the Department of Energy, the Air Force Office of Scientific Research, the National Security Agency, and the National Science Foundation. The sponsors are UTK's Departments of Computer Science and Mathematics and the Mathematical Sciences Section of ORNL's Engineering Physics and Mathematics Division.

The Early Years of Numerical Linear Algebra at ORNL

When the first large computers became available in the 1950s, researchers at ORNL were among the leaders in the development of tools for numerical linear algebra. One of the pioneers in the field was Alston S. Householder, formerly a UTK faculty member and head of ORNL's Mathematics Division, which was formed in 1962 from the Mathematics Panel he had set up in 1948. Householder's research in numerical linear algebra began with ORNL's acquisition of the Oak Ridge Automatic Computer and Logic Engine (ORACLE), one of the nation's earliest vacuum-tube computers. Now retired and living in Malibu, California, Householder was an honored attendee at this year's Gatlinburg.

Many distinguished mathematicians and computer scientists, among them Wallace Givens and G.W. Stewart, joined Householder's staff during his career at ORNL and UTK. Leading experts in numerical linear algebra from all over the world, including James Wilkinson from England and Fritz Bauer from West Germany, were visiting collaborators.

Two of the most fundamental tools of numerical linear algebra—Householder reflections and Givens rotations—were developed at ORNL in the 1950s. These transformations are still widely used to simplify the complex matrix problems encountered in such applications as the design of bridges and earthquake-resistant buildings.

The Gatlinburgs

The Tenth International Symposium on Numerical Algebra was the most recent of a series, officially dating back to 1961 and known informally as the Gatlinburgs, that grew out of the early work in numerical linear algebra done at ORNL. The series actually had two predecessors that set the stage for the ten symposia to come.

In 1951 UCLA hosted a symposium entitled Simultaneous Linear Equations and the Determination of Eigenvalues. Financed by the Office of Naval Research, sponsored by the Institute for Numerical Analysis of the National Bureau of Standards, and organized by Olga Taussky, the symposium was the occasion for the presentation of some important work. George Forsythe presented his "tentative classification and bibliography of methods for solving systems of linear equations," with a bibliography of about 50 titles. In addition, two new developments were introduced by speakers at the symposium. Givens gave a preliminary report on his tridiagonalization method, and Barkley Rosser, Magnus Hestenes, and Eduard Stiefel discussed the conjugate gradient method.

Six years after the UCLA symposium, Givens organized a somewhat similar symposium, which was held at Wayne State University in Detroit. Entitled Conference on Matrix Computations, the event featured many speakers not on the UCLA program, among them Cornelius Lanzos, Peter Henrici, Richard Varga, Herbert Keller, Bauer, Wilkinson, and Young.

Three years later, a group of people interested in matrices, including Householder, felt that it was time to come for a third conference on matrix computations. The result of their planning was Gatlinburg I, which was held in 1961. The format and philosophy of that meeting have been preserved, on the whole, in the subsequent meetings of the series.

In general, the symposia are to be international one-week working sessions of limited scope and with limited attendance. To encourage informal, unscheduled discussion among participants, the program for the first Gatlinburg was deliberately limited to two one-hour invited presentations each morning and afternoon. Location has been an important consideration for the organizers of all the Gatlinburgs—the ideal location has beautiful scenery, pleasant accommodations, and, perhaps most important, a lack of distractions, like theaters and nightclubs. The Mountain View Hotel in Gatlinburg satisfied the criteria and, in fact, was the site of the first four Gatlinburgs.

Householder organized the first four Gatlinburgs. Among the many details to be arranged were financing—obtained from

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the National Science Foundation and the U.S. Atomic Energy Commission (AEC)—and sponsorship—provided by SIAM. SIAM has continued its involvement in the Gatlinburgs, and the SIAM Activity Group on Linear Algebra co-sponsored the most recent of the series.

One unforeseen result of the Gatlinburgs was the birth of a new SIAM journal. Gatlinburg II again was funded in part by AEC, with the stipulation that a proceedings be published. SIAM's decision to launch a journal on numerical analysis coincided with the need of the Gatlinburg organizers for a publisher, and the first issue contained papers from Gatlinburg II. Later meetings, supported entirely by NSF, had no such publishing requirements, and speakers were free to publish their papers as they chose.

Subsequent Gatlinburgs followed the 1961 meeting at varying intervals. Frank Olver was responsible for the program and invitations for Gatlinburg II, which took place in 1963, on approximations; the focus of Gatlinburg III, held one year later, was unforeseen result of the Gatlinburgs again on matrices. Although five years elapsed between Gatlinburgs III and IV, conferences held elsewhere involved many of the participants and themes of the Gatlinburgs.

Los Alamos, which in its own way provided the ambiance sought by the organizers of the earliest Gatlinburgs, was the site chosen for the fifth symposium in the series, held in 1972. Referred to as Gatlinburg V despite the change in location, it was organized by Richard Varga and followed the format of its predecessors. Fritz Bauer organized Gatlinburg VI, held in a similarly remote, beautiful spot, this time in the Bavarian Alps, about 100 miles from Munich, in 1975.

From Germany the series moved to Asilomar, California—on the Monterey Peninsula—under the leadership of Gene Golub in 1977. Although still a working meeting, the 1977 Gatlinburg had a larger attendance as a result of Golub's invitation to the community to submit papers for inclusion. Oxford, England, was the site of the meeting organized by Leslie Fox and James Wilkinson in 1980, and Alan George organized a symposium that drew about 140 participants to Waterloo, Ontario, Canada, in 1984.
History of ORNL

Oak Ridge National Laboratory, originally Clinton Laboratories, was established in 1943 as the pilot plant for demonstrating the safe production of plutonium-239, a fissionable man-made element. Since 1943 ORNL has made numerous contributions in the biological and physical sciences, as well as in engineering. Its main mission has been the safe, economical production and use of energy, particularly nuclear energy. Among ORNL's achievements are:

- Development of safe chemical methods for reprocessing nuclear fuels.
- Development of advanced nuclear systems, such as breeder and fusion reactors.
- Development of coal conversion, energy conservation, and solar electric technologies.
- Determination of the risks to health and the environment posed by radiation and radionuclides from nuclear facilities and waste burial sites and by chemical contaminants from non-nuclear facilities.
- Development of more than 50 technologies recognized for their commercial potential (with rights to commercialize the technologies acquired by more than 15 private firms).

From 1948 to 1984 ORNL was operated by Union Carbide Corporation's Nuclear Division for AEC (until 1975), the Energy Research and Development Administration (until 1978), and the U.S. Department of Energy (since 1978). For the past three and a half years, ORNL has been operated for DOE by Martin Marietta Energy Systems, Inc.

Today, a core of researchers at ORNL and UTK are using numerical linear algebra to perform large-scale matrix computations on parallel computers. Robert C. Ward, head of ORNL's Mathematical Sciences Section and co-organizer, with G.W. Stewart, of this year's Gatlinburg, considers ORNL a rich source of problems in numerical linear algebra. Of Numerical Linear Algebra Year, Ward says, "Visiting mathematicians and computer scientists will have a unique opportunity to interact with scientists at ORNL at the forefront of knowledge in their own areas of expertise. From this information exchange, the visitors can contribute to computational modeling of complex phenomena, such as the movement of contaminants through the atmosphere and soil."

In the 1950s the Oak Ridge area was a hotbed of mathematical activity, with Householder and Givens developing fundamental new tools for numerical linear algebra and attracting a variety of mathematical experts to the area. The current group of researchers and the numerous visiting mathematicians and computer scientists expected during Numerical Linear Algebra Year give ORNL and UTK reason to anticipate new peaks in mathematical achievement.


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high metallic arms, and each seat back is crowned with an aluminum semicircle. Ensnoked in that protective chair, one among many in the great hall, I felt not like a mathematician or a tourist, but like a member of some outer space senate awaiting a speech by Flash Gordon.

Regrettably, my space fantasies ended all too soon. I was beamed back to reality to begin contemplating ICIAM '91, to be held four years hence in Boston. The trip won't be quite such an adventure next time, but there is some small comfort in knowing that the drivers will be almost as crazy.

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