REMEMBERING STAVROS BUSENBERG

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Abstract

This note provides the introduction to a memorial volume for Stavros Busenberg who died on April 3, 1993 after a very short and difficult battle with amyotrophic lateral sclerosis (ALS) also known as Lou Gehrig's disease. We highlight his work as a teacher and scholar.

Remembering Stavros Busenberg

Stavros Busenberg was born to Greek parents in Jerusalem in 1941. With his family, he emigrated to the United States in 1958. He took a bachelor's degree in mechanical engineering from the Cooper Union in New York City, and two master's degrees from the Illinois Institute of Technology (IIT): one in mechanical engineering and one in mathematics. In 1967, he received his Ph.D. in Mathematics from IIT, where his dissertation supervisor was John DeCicco. He held a post-doctoral position at the North American Science Center of the Rockwell Corporation before joining the faculty at Harvey Mudd College in 1968. He remained at Harvey Mudd, but held visiting or sabbatical positions at Stanford University, Oak Ridge National Laboratory, Caltech, Oxford University, the Università di Trento, the University of Victoria, Massey University, and the University of Bordeaux II.

In 1966, Stavros met Bonnie Egan in Chicago. Three years later, in 1969, they were married at Sage Chapel in Cornell University where Bonnie was a graduate student in biology. They had two children: George, born in 1971, and John, born in 1972. Stavros believed in the Greek ideal of developing both his mind and his body. He was very athletic, played varsity volleyball in college, earned a black belt in judo, and hiked, bicycled, and played tennis and squash all of his adult life. He loved classical music and opera, and was a devotee of poetry and could recite verses in several languages. He loved plants, and took pride in the fruit trees and vines that he and Bonnie cultivated in their yard. He also liked to travel and to speak other languages, for which he had a considerable gift – he spoke Greek, French, Italian, English, and some Arabic.

Stavros had complained of trouble with his leg muscles in the summer of 1992. In October, he was diagnosed as suffering from amyotrophic lateral sclerosis (ALS), also known as Lou Gehrig's disease. By January he was unable to stand and was using a wheelchair. Nevertheless, he continued to teach until the last week of his life. Furthermore, he continued to work with Betty Tang, who had received an NSF award to collaborate with Stavros. Many of his friends and collaborators continued to visit him until the very end. Our visits focused on serious research discussions about our current joint work. We will always remember his deep concentration as he guided our hands through complex computations over a small white board. He died on April 3, 1993.

Stavros loved teaching and always wanted to be a teacher. He taught night classes at IIT for Chicago residents who were trying to get their degrees with part time study, and later taught at Loyola in Chicago while he was writing his dissertation. He was one of the most popular mathematics professors at Harvey Mudd College. He was a great extemporaneous lecturer and did not spend a lot of time preparing. He said the material was "in his bones." He liked to have bright undergraduate students work with him on research, and spent a great amount of time helping them to understand the required background and get up to the frontiers. Several undergraduate students published papers jointly with him, and many continued on to obtain graduate degrees.

Throughout his academic career, Stavros maintained a strong interest in the application of mathematics to industrial problems. He frequently served as co-director of the Claremont Colleges Mathematics Clinic and as director of the HMC Mathematics Clinic, programs in which student teams tackled and solved real-world problems of interest to sponsoring companies. He supervised the first clinic project in 1973 and eight subsequent projects. One recent project resulted in the procurement of two patents for high-resolution video cameras. During the summer of 1989, as a Fulbright Research Professor at Massey University in New Zealand, he participated in the establishment of a university-industry program in applied mathematics. He also co-directed two workshops held at Claremont focused on industrial mathematics: Modern Computational Methods in Industrial Mathematics (1991) and Semiconductor Simulation (1992), sponsored by the Army Research Office.

Stavros was eager to promote advances in mathematics and in the careers of younger researchers, and believed that research conferences were important means toward those objectives. He helped to organize the International Conference on Experiential Applied Mathematics Education sponsored by NSF in May, 1979, and sessions on differential equations at several AMS and SIAM meetings. He was an organizer or co-director of several conferences in Claremont, including the NSF-CBMS conferences on Topological Degree Methods in Nonlinear Boundary Value Problems in 1977 and on Global Topological Methods in Applied Mathematics in 1981, the International Conference on Differential Equations and Applications to Ecology, Epidemics, and Population Problems in 1981, the SIAM meeting on University-Industry Collaborations in Mathematics, in January, 1987, and the Conference on Differential Equations and Applications in Biology and Population Dynamics in 1990.

Much of Stavros' work was on differential equations and on mathematical biology, but it embraced a number of other areas in pure and applied mathematics. It was distinguished for its choice of interesting problems and use of creative techniques, ranging from semigroup methods to clever transformations and hard analysis. Among his most important and lasting work was research on the formulation and solution of nonlinear equations that

model population dynamics, the spread of infectious diseases, and the cell cycle. He made significant contributions to the formulation and analysis of systems of partial differential equations that model age-dependent population dynamics, and to nonlinear diffusion equations. This part of his work culminated when he combined the two topics in two 1983 papers on population dynamics in separable models with both nonlinear diffusion and age-structure. The powerful technique developed in this context resurfaced in a 1986 paper on nonlinear degenerate parabolic equations. He began his work on the transmission of infectious diseases with a 1978 paper on periodic solutions of a nonlinear delay differential equation, and continued with papers on general theory as well as on models of particular diseases. He became one of the leading experts on vertical transmission. This particular interest led him to include age structure and to show that making the transmission rates age-dependent does not change the global stability of an endemic system with susceptibles and infectives only. In a recent contribution of fundamental importance, he provided a general way to understand all possible "mixing" structures in stratified populations. These ideas are now finding additional applications in demography, paired-event probability theory, and the modeling of social dynamics. He emphasized the importance of the interaction of demography and epidemiology and identified the key parameters governing the bifurcation phenomena that occur. The title that he selected for one of our last theorems on "mixing" was characteristic of his keen sense of humor. In an e-mail note in March of last year, he states: "let's call this result 'the 'T^3 Theorem', because we have just proved that 'It Takes Two to Tango'."

His contributions in other areas included the study of approximations of functional differential equations by ordinary differential equations, of geometric irregularities in normed spaces, and the derivation of bounds for periods of periodic orbits of dynamical systems. Not long ago, he began to work on the mathematics of semiconductors. He took great joy in his research and attracted many collaborators, and more than 30 co-authors were stimulated and inspired by his contagious enthusiasm. He worked very hard, often late at night when his family was in bed. Until a few days before his death, he continued to work with friends who came to Claremont to see and consult with him. Some of the articles in this issue represent work that was commenced or continued during this time.

Stavros wrote more than 75 research papers and wrote or edited five books. His most recent book, *Vertically Transmitted Diseases: Models and Dynamics*, appeared in January, 1993 in the Biomathematics Series of Springer-Verlag. He was associate editor of the *Journal of Mathematical Analysis and Applications* and a member of the editorial board of the *Journal of Mathematical Biology.* He was a thesis adviser and counselor to many graduate students at the Claremont Graduate School, and a strong and active supporter of underrepresented minorities and women in the sciences.

Stavros had a powerful analytical mind, an intense interest in both the sophisticated theories of mathematics and in their application to scientific and industrial problems, and a love for research and teaching. The articles in this memorial volume will give but a small glimpse of some of the research areas to which Stavros was a major contributor.

We who worked with him know what a creative, generous, and inspiring collaborator he was. The courage and determination that he showed over the last months of his life were but his last gifts to his family, his friends, and the profession. We remember him with affection, admiration, and a sense of great loss that he is gone.

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