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Obituaries: Richard Ewing

Richard Ewing, 1946–2007

Richard Ewing died suddenly on the evening of December 5, 2007, at the age of 61, leaving both the local community and colleagues worldwide stunned. As a testament to the loss, a vast outpouring of condolences and tributes were posted on the Web site of Texas A&M's Institute for Scientific Computation, which he founded in 1992. Several hundred of the postings were of course from mathematicians and scientists with whom Dick had worked, but it is a tell-ing indication of the man that they did not make up the majority of those who wished to pay their respects.

Dick came from an academic family. Both his parents were historians; his mother was a schoolteacher, and his father worked at several universities before becoming a professor of history at Texas A&M. Two uncles, John and Maurice, were research geophysicists: Maurice Ewing was among the most distinguished marine geophysicists working in the period of extraordinary advances that followed the Second World War. As an undergraduate Dick would spend time during the summers on his uncle's research vessel; while he was not tempted away from a mathematical career, his work took on what would become a long-lasting and increasing geophysical orientation shortly after he received his PhD.

He entered the University of Texas in 1965 and over the next nine years gained his BA, MA, and PhD. While a Phi Beta Kappa scholar, he also had time for a social outlook; he was a first-rate tennis player and an avid member of the UT marching band. It was there that he met his future wife, Rita (although the complete truth is that Rita joined the band specifically to "march with Dick").

Dick completed his doctorate at the University of Texas in 1974, under the supervision of John Cannon. His thesis was on a classic problem, the solution of the backward heat equation [4], and was influenced heavily by Ralph Showalter. The "usual," well-posed problem here is to be given initial data $u_0(x,0)$ and to determine the spatial solution profile at a later time $u_f(x,T)$. The inverse problem is to be given $u_f(x,T)$ and seek the initial configuration u_0. This is an extremely ill-conditioned problem. The trick used was to replace the heat operator $e^{t\triangle}$ by its Yosida approximant $e^{t(I-\varepsilon\triangle)^{-1}\triangle}$, which had the effect of replacing the parabolic equation $u_t - \triangle u = 0$ by the pseudo-parabolic or Sobelev equation $u_t - \varepsilon\triangle u_t - \triangle u = 0$. The heat operator generates a semi-group, whereas its Yosida approximant is a group for all $\varepsilon > 0$. For $\varepsilon > 0$ the backward or inverse problem is now well-posed, and one approximates the original problem by letting $\varepsilon \to 0$ in a controlled sense. We would recognize this today as an example of a regularization scheme. While Dick's interest lay directly in inverse problems for only a few years, the theme and, in particular, the technique of replacing the original operator by one that is "better behaved" remained throughout his work.

His first position was at Oakland University. In 1976 he went to the University of Chicago for the first year of a National Science Foundation postdoctoral fellowship, moving to Ohio State for the second year and to the Mathematics Research Center at the University of Wisconsin for the third. This was a career-setting time, for he exchanged the PDE-centric emphasis of his work for a numerical-analysis-for-PDE position. Jim Douglas was a defining influence here, as were many of the collaborations formed during this time, in particular with Jim Bramble, Tom Russell, and Mary Wheeler. The Douglas–Ewing–Wheeler [3] paper on applying mixed finite element methods to Darcy flow in porous media was a breakthrough. Mixed methods quickly became a staple for problems of this type and are still widely used in engineering applications. Dick would continue to work and make important contributions in this area throughout his career. Examples include obtaining optimal error estimates [6] and the concept of using "superconvergence" to enhance accuracy, which was developed with a number of colleagues, including Raytcho Lazarov and Junping Wang [5]. The idea here is to use additional smoothness properties of the solutions to "post-process" the numerical computations into a more accurate final solution.

The position at Ohio State was quite short term; in 1980 Dick left to work at Mobil Oil in Dallas. The integration of geophysics into his work was now complete and would dominate the targeted applications for the remainder of his career. For example, one approach to the solution of convection–diffusion–reaction equations and systems, which is widely applied to petroleum engineering problems, is the Eulerian–Lagrangean localized adjoint method (ELLAM) developed by Celia, Russell, Herrera, and Ewing [2]. This numerical method, which discretizes the total time derivative (the local time derivative plus the convective term), overcomes the principal shortcomings of many previous characteristic methods while maintaining the numerical advantages of such schemes. The ELLAM methodology has been incorporated into many codes for both reservoir simulation and groundwater flows.

Two years later, in 1982, the Ewings moved to the University of Wyoming, leaving a decade after that for Texas A&M. Although Dick came to College Station as dean of science and later served as vice president for research, he remained research-active and productive throughout his career and left numerous unfinished manuscripts at his death.

Dick is probably best known for his work on preconditioning methods for the numerical solution of partial differential equations, especially those arising in multiphase flows in porous media. Here there is a coupled nonlinear system consisting of a hyperbolic equation and a (frequently) degenerate elliptic–parabolic system, the latter causing the bulk of the computational issues.

The convergence rate of iterative methods depends heavily on the spectral properties of the coefficient matrix A. For conjugate gradients, the number of iterations needed for convergence is often of the order of the square root of the condition number of A. Thus, if the lowest-magnitude eigenvalues of A are far from the origin, convergence is relatively rapid. If eigenvalues are clustered close to the origin, convergence is slow. A preconditioning matrix M speeds up an iterative solution to the system $Ax = b$. The goal is to find a matrix M that is "near" A—so that the eigenvalues of $M^{-1}A$ are all near 1 (and the condition number thus near unity) and yet M^{-1} is "close to" A^{-1}. We then solve the "preconditioned" system $M^{-1}Ax = M^{-1}b$. While there are some general preconditioners, selecting M is as much an art as a science, and enormous speedups can be obtained by tailoring M to the specific problem—or in this case to the structure of the underlying PDE being solved.

One of the best known results for preconditioning pertaining to finite elements is the so-called Bramble–Ewing–Pasciak–Schatz (BEPS) method [1]. The fundamental idea was to incorporate preconditioning and local grid refinement within a grid structure, which made a simpler implementation possible and avoided the complicated structures associated with general grid refinement strategies. It was shown that for second-order elliptic problems, mesh-size-independent preconditioning could be built in terms of solvers or preconditioners for regular grids—and these building blocks existed and were already well understood at the time.

In a slightly different direction, a paper co-authored by Junping Wang [7] was the first to develop preconditioners for "degenerate" elliptic systems, that is, quadratic forms corresponding to H(div) or H(curl). The analysis involved separate examination of the behavior of discrete gradients and discrete divergence-free components, and the approach became central to an industry that was developed to handle preconditioning of such problems.

Dick produced an enormous volume of work—more than 330 papers published in journals and conference proceedings with more than 100 co-authors. He would write papers in his office, in hallways, and on planes, and one was even written at a dog show (Rita and the Ewing plus Wheeler kids were there for the main event; Dick and Mary were working on error estimates). Where did he find the time to do all this, in addition to his administrative day jobs of the last fifteen years and an obvious dedication of time and energy to his family? It was certainly evident that the more things he could juggle, the more energized he seemed to become. Another observation was his firm advocacy of the principle that a 5-minute nap in a meeting or lecture was worth an hour in bed.

His true legacy, however, may lie not in the contributions of his papers but in the sheer number of people he influenced by encouraging, mentoring, or inspiring. What immediately set Dick apart was his presence. He had a "hard-to-describe, but obvious-when-you-see-it" ability to attract. People would naturally gravitate toward him in a room, and he could hold court yet say less than anybody else. He had so many collaborators in part because he had a knack for spotting opportunities to combine the immense amount he knew with the expertise of others, but also, and maybe mainly, because with his quiet magnetism he was so easy to talk to. But this reveals only part of the picture. It has been said that you can tell a man by what he does for others who cannot possibly repay the debt. For many, this will be Dick's defining characteristic.—*William Rundell, Texas A&M University.*

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