KENDALL EUGENE ATKINSON: AN APPRECIATION

C.W. GROETSCH AND M.Z. NASHED

1. Dedication. In June 2005, Kendall Eugene Atkinson retired as Professor Emeritus of Mathematics and Computer Science, after a long and distinguished career at the University of Iowa. This special issue of the Journal of Integral Equations and Applications is dedicated to Ken Atkinson in appreciation of his many contributions to the theory and practice of numerical methods for the treatment of integral equations and his years of exemplary editorial service to the Journal and dedication to the profession. The papers in this issue, spanning many areas of integral equations and related topics, from the theoretical to the numerical, and from the applied to the computational, are all dedicated to Ken by their authors, with respect and admiration. They are testimony of the high professional esteem and warm personal friendship in which Ken is held by his colleagues and peers.

2. A biographical sketch. Kendall Eugene Atkinson, an Iowan right down to the bone, was born in Centerville, Iowa, on March 23, 1940. The Atkinson family roots in Iowa stretch back to antebellum times. Ken's father, Harold Eugene Atkinson, was compelled by the economic hardships of the Great Depression to abandon his pre-law studies at Grinnell College; he turned to farming for a time, and then became a seed broker and expert on hybrid corn. Harold Atkinson rose to a vice presidency of the Corn States Hybrid Service and served as president of the Iowa Seed Dealers Association. Helen Fleming Atkinson, Ken's mother, is a graduate of Drake University and a retired teacher. She entered the profession while still 17 years old, in a one-room Iowa school house, and had a long career devoted to teaching the handicapped.

Ken attended elementary and secondary schools in Des Moines and entered Iowa State University as a student of mathematics and physics in 1958. Upon graduation in 1961 he was married to Alice Morse, a union that has produced two daughters, Elizabeth and Kathryn. The newlyweds headed to the University of Wisconsin where Ken held a

Mathematics Research Fellowship. It is characteristic of the Atkinson's that upon Ken's receiving his master's degree in 1963, Ken and Alice heard, and responded to, the call to humanitarian service and joined the Peace Corps. The Atkinsons spent the years 1963–64 in Addis Ababa, Ethiopia, Alice teaching high school home economics and Ken teaching mathematics in a university laboratory school. Ken and Alice returned to the University of Wisconsin in 1964, where Ken wrote his dissertation under the supervision of Ben Noble and was awarded the Ph.D. degree in 1966.

Ken's first full time academic appointment was at Indiana University beginning in 1966. He attained the rank of associate professor at I.U. in 1972 and joined the faculty of mathematics at the University of Iowa as Associate Professor of Mathematics in the same year. At Iowa Ken rose to the rank of Professor of Mathematics (1975) and Professor of Computer Science (1997). In the mid-sixties Ken began work on his *Introduction to Numerical Analysis* which, after its publication in 1978, became a canonical numerical analysis text at the senior-graduate level and continues to enjoy a longevity that is rare for any mathematics textbook. In 1985 Ken published his *Elementary Numerical Analysis*, a book aimed at attracting students to the subject at an earlier stage of their studies. This book was also a big success and now is in its third edition, coauthored with Weimin Han. This was followed by two important higher level books, his book on numerical methods for second kind integral equations, published by Cambridge University Press in 1997 and his book with Weimin Han on the functional analysis background for numerical analysis (Springer, 2001). Given this interest in mathematical exposition, it should come as no surprise that Ken has always been known for his dedication to teaching and his mentoring of students, at both the undergraduate and graduate levels. His work with students was recognized by his colleagues with the 1995 *Collegiate Teaching Award* of the University of Iowa.

Ken has had a close and continuing relationship with the Australian mathematics community since his Indiana days. This began with a research fellowship at Australian National University in 1970–71, during which time his SIAM monograph of 1976 was conceived. He has returned to Australia several times since then to assume visiting positions at the University of New South Wales, the University of

Queensland and the Commonwealth Scientific and Industrial Research Organization in Canberra.

Ken has a sterling record of service to the profession. He has served with distinction on the editorial boards of the *SIAM Journal on Numerical Analysis*, the *Journal of Integral Equations and Applications* and *Advances in Computational Mathematics*; he was an officer on the Society for Industrial and Applied Mathematics Council and the Association for Computing Machinery Special Interest Group in Numerical Mathematics (SIGNUM), and a member of the SIAM Education Committee. While Ken has retired from full-time teaching duties, he continues to be a highly valued and active member of the numerical analysis research community.

3. The mathematics of Kendall Atkinson. Since his 1966 dissertation on Extensions of the Nyström Method, Ken Atkinson has produced important results on almost all aspects of numerical methods for (mainly second kind) integral equations. He has also made contributions to associated problems in approximation theory, the theory of quadrature methods, and aspects of constructive fixed point theory and the theory of collectively compact operators. His 1976 SIAM monograph was the first book published in English to be entirely devoted to numerical methods for integral equations of the second kind. Its inclusion of fully developed Fortran programs for Fredholm integral equations of the second kind resulted in its particularly warm welcome by the research community.

If one wanted an exemplar of Ken Atkinson's analytical prowess, then his 1973 paper on numerical evaluation of fixed points of completely continuous nonlinear operators is the place to look. In this paper the spirit of the theory of collectively compact operator theory is extended to approximation of fixed points of nonlinear integral operators by applying Krasnoselskii's theory of homotopy invariance of the rotation of a completely continuous vector field. The theory is applied to approximate the solution of a Urysohn integral equation by use of an approximating sequence of numerical integration operators and an extension of the theory to singular kernels (including the Nekrasov equation in hydrodynamics) via product integration techniques is laid out.

A major effort of Ken Atkinson's research over the years has been the theory and application of numerical methods for integral equations associated with problems in potential theory in two and three dimensions. His work on boundary integral equation methods (BIEM) is widely recognized and his 1996 survey paper on BIEM in *The State of the Art in Numerical Analysis* is a must read for anyone wishing to gain acquaintance with the method. In addition to his analytical work on the BIEM, Ken has written and developed the widely distributed software package BIEPACK for solving boundary integral equations on surfaces. In recent years Ken has applied and extended his research on BIEM to the numerical solution of the "radiosity equation," an integral equation arising in the theory of radiative heat transfer and computer graphics. Version #2 of BIEPACK, released in 1998, includes routines for solving the unoccluded radiosity equation on surfaces in three-dimensional space. Ken is also currently working on some nonlinear integral equations arising in potential theory and applying recent research on multivariate polynomial approximations, numerical quadrature techniques and orthogonal polynomial expansions to problems in nonlinear multivariable potential theory.

The range and depth of Kendall Atkinson's research in numerical analysis and related fields is truly impressive. A list of his publications to date appears below.

4. Publications of Kendall Atkinson.

Books

A Survey of Numerical Methods for the Solution of Fredholm Integral Equations of the Second Kind, Society for Industrial and Applied Mathematics, Philadelphia, 1976.

An Introduction to Numerical Analysis, John Wiley and Sons, New York, 1978 (2nd ed., 1989).

Elementary Numerical Analysis, John Wiley and Sons, New York, 1985 (2nd ed., 1993; 3rd ed. with Weimin Han, 2004).

The Numerical Solution of Integral Equations of the Second Kind, Cambridge University Press, Cambridge, 1997.

Theoretical Numerical Analysis : A Functional Analysis Framework, with Weimin Han, Springer, New York, 2001 (2nd ed., 2005).

Articles

1967

The numerical solutions of the eigenvalue problem for compact integral operators, Trans. Amer. Math. Soc. **129** (1967), 458–465.

The solution of non-unique linear integral equations, Numer. Math. **10** (1967), 117–124.

The numerical solution of Fredholm integral equations of the second kind, SIAM J. Numer. Anal. **4** (1967), 337–348.

1968

On the order of convergence of natural cubic spline interpolation, SIAM J. Numer. Anal. **5** (1968), 89–101.

1969

K. Atkinson and A. Sharma, *A partial characterization of poised Hermite-Birkhoff interpolation problems*, SIAM J. Numer. Anal. **6** (1969), 230–235.

The numerical solution of integral equations on the half-line, SIAM J. Numer. Anal. **6** (1969), 375–397.

1970

R.P. Gilbert (with an Appendix by Kendall E. Atkinson), *Integral operator methods for approximating solutions of Dirichlet problems, Iterationsverfahren, Numerische Mathematik, Approximationstheorie* (Tagung Numer. Method. Approximationstheorie, Oberwolfach, 1969), Internat. Schriftenreihe Numer. Math., vol. 15, Birkhäuser, Basel, 1970, pp. 129–146.

1972

The numerical solution of Fredholm integral equations of the second kind with singular kernels, Numer. Math. **19** (1972), 248–259.

The numerical evaluation of the Cauchy transform on simple closed curves, SIAM J. Numer. Anal. **9** (1972), 284–299.

1973

The numerical evaluation of fixed points for completely continuous operators, SIAM J. Numer. Anal. **10** (1973), 799–807.

Iterative variants of the Nyström method for the numerical solution of integral equations, Numer. Math. **22** (1973/74), 17–31.

1974

An existence theorem for Abel integral equations, SIAM J. Math. Anal. **5** (1974), 729–736.

The numerical solution of an Abel integral equation by a product trapezoidal method, SIAM J. Numer. Anal. **11** (1974), 97–101.

1975

Convergence rates for approximate eigenvalues of compact integral operators, SIAM J. Numer. Anal. **12** (1975), 213–222.

1976

An automatic program for linear Fredholm integral equations of the second kind, ACM Trans. Math. Software (2) **2** (1976), 154–171.

1977

The numerical solution of a bifurcation problem, SIAM J. Numer. Anal. (4) **14** (1977), 584–599.

1980

The numerical solution of Laplace's equation in three dimensions, II, in *Numerical Treatment of Integral Equations*, (Workshop, Math. Res. Inst., Oberwolfach, 1979), Internat. Ser. Numer. Math., vol. 53, Birkhäuser, Basel-Boston, 1980, pp. 1–23.

1981

Numerical integration on the sphere, J. Austral. Math. Soc. Ser. B **23** (3) (1981/82), 332–347.

1982

The numerical solution of Laplace's equation in three dimensions, SIAM J. Numer. Anal. (2) **19** (1982), 263–274.

Kendall E. Atkinson and Frank deHoog, *Collocation methods for a boundary integral equation on a wedge*, in *Treatment of Integral Equations by Numerical Methods* (C.T.H. Baker and G.F. Miller, eds.), Academic Press, London, 1982, pp. 253–260.

1983

K. Atkinson, I. Graham and I. Sloan, *Piecewise continuous collocation for integral equations*, SIAM J. Numer. Anal. (1) **20** (1983), 172–186.

1984

K. Atkinson and F. de Hoog, *The numerical solution of Laplace's equation on a wedge*, IMA J. Numer. Anal. (1) **4** (1984), 19–41.

1985

The numerical evaluation of particular solutions for Poisson's equation, IMA J. Numer. Anal. (3) **5** (1985), 319–338.

Solving integral equations on surfaces in space, in *Constructive Methods for the Practical Treatment of Integral Equations* (Oberwolfach, 1984), Internat. Schriftenreihe Numer. Math., vol. 73, Birkhäuser, Basel, 1985, pp. 20–43.

Algorithm 629, *An integral equation program for Laplace's equation in three dimensions*, ACM Trans. Math. Software (2) **11** (1985), 85–96.

Piecewise polynomial collocation for integral equations on surfaces in three dimensions, J. Integral Equations (1) **9** suppl. (1985), 25–48.

1987

Kendall Atkinson and Alex Bogomolny, *The discrete Galerkin method for integral equations*, Math. Comp. (178) **48** (1987), 595–616.

Kendall E. Atkinson and Florian A. Potra, *Projection and iterated projection methods for nonlinear integral equations*, SIAM J. Numer. Anal. (6) **24** (1987), 1352–1373.

1988

Kendall E. Atkinson and Ivan G. Graham, *An iterative variant of the Nyström method for boundary integral equations on nonsmooth boundaries*, in *The Mathematics of Finite Elements and Applications* VI (Uxbridge, 1987), Academic Press, London, 1988, pp. 297–303.

Kendall Atkinson and Florian Potra, *The discrete Galerkin method for nonlinear integral equations*, J. Integral Equations Appl. (1) **1** (1988), 17–54.

A discrete Galerkin method for first kind integral equations with a logarithmic kernel, J. Integral Equations Appl. (3) **1** (1988), 343–363.

1989

K.E. Atkinson and F.A. Potra, *On the discrete Galerkin method for Fredholm integral equations of the second kind*, IMA J. Numer. Anal. **9** (1989), 385–403.

1990

A survey of boundary integral equation methods for the numerical solution of Laplace's equation in three dimensions, in *Numerical Solution of Integral Equations* (M.A. Golberg, ed.), Math. Concepts Methods Sci. Engrg., vol. 42, Plenum, New York, 1990, pp. 1–34.

Kendall E. Atkinson and Graeme Chandler, *Boundary integral equation methods for solving Laplace's equation with nonlinear boundary conditions*: *The smooth boundary case*, Math. Comp. **55** (1990), 451–472.

1991

Kendall E. Atkinson and Ian H. Sloan, *The numerical solution of first-kind logarithmic-kernel integral equations on smooth open arcs*, Math. Comp. **56** (1991), 119–139.

1992

A survey of numerical methods for solving nonlinear integral equations, J. Integral Equations Appl. **4** (1992), 15–46.

Kendall E. Atkinson and Ivan G. Graham, *Iterative solution of linear systems arising from the boundary integral method*, SIAM J. Sci. Statist. Comput. **13** (1992), 694–722.

1993

Ivan G. Graham and Kendall E. Atkinson, *On the Sloan iteration applied to integral equations of the first kind*, IMA J. Numer. Anal. **13** (1993), 29–41.

K. Atkinson and J. Flores, *The discrete collocation method for nonlinear integral equations*, IMA J. Numer. Anal. **13** (1993), 195–213.

K. Atkinson and E. Venturino, *Numerical evaluation of line integrals*, SIAM J. Numer. Anal. **30** (1993), 882–888.

1994

The numerical solution of a non-linear boundary integral equation on smooth surfaces, IMA J. Numer. Anal. **14** (1994), 461–483.

Two-grid iteration methods for linear integral equations of the second kind on piecewise smooth surfaces in R^3, SIAM J. Sci. Comput. **15** (1994), 1083–1104.

1995

Yajun Yang and Kendall E. Atkinson, *Two-dimensional quadrature for functions with a point singularity on a triangular region*, SIAM J. Numer. Anal. **32** (1995), 969–983.

Kendall E. Atkinson and David Chien, *Piecewise polynomial collocation for boundary integral equations*, SIAM J. Sci. Comput. **16** (1995), 651–681.

1997

The numerical solution of boundary integral equations, in *The State of the Art in Numerical Analysis* (York, 1996), Inst. Math. Appl. Conf. Ser. New Ser., vol. 63, Oxford Univ. Press, New York, 1997, 223–259.

Ian H. Sloan and Kendall E. Atkinson, *Semi-discrete Galerkin approximations for the single-layer equation on Lipschitz curves*, J. Integral Equations Appl. **9** (1997), 279–292.

David Da-Kwun Chien and Kendall Atkinson, *A discrete Galerkin method for a hypersingular boundary integral equation*, IMA J. Numer. Anal. **17** (1997), 463–478.

1998

Kendall Atkinson and Graeme Chandler, *The collocation method for solving the radiosity equation for unoccluded surfaces*, J. Integral Equations Appl. **10** (1998), 253–290.

K.E. Atkinson and Y. Xu, eds., *Numerical treatment of boundary integral equations*, Adv. Comput. Math. **9** (1998), Baltzer Science Publishers BV, Bussum, 1998, pp. iii–viii and 1–249.

2000

Kendall Atkinson and David Da-Kwun Chien, *A fast matrix-vector multiplication method for solving the radiosity equation*, Adv. Comput. Math. **12** (2000), 151–174.

Kendall Atkinson, *The planar radiosity equation and its numerical solution*, IMA J. Numer. Anal. **20** (2000), 303–332.

Kendall Atkinson, David Da-Kwun Chien, and Jaehoon Seol, *Numerical analysis of the radiosity equation using the collocation method*, Electron. Trans. Numer. Anal. **11** (2000), 94–120 (electronic).

2003

Hongling Wang, Joseph Kearney and Kendall Atkinson, *Arc-length parameterized spline curves for real-time simulation, Curve and surface design* (Saint-Malo, 2002), Modern Methods Math., Nashboro Press, Brentwood, TN, 2003, pp. 387–396.

Hongling Wang, Joseph Kearney and Kendall Atkinson, *Robust and efficient computation of the closest point on a spline curve, Curve and surface design* (Saint-Malo, 2002), Modern Methods Math., Nashboro Press, Brentwood, TN, 2003, pp. 397–405.

2004

Quadrature of singular integrands over surfaces, Electron. Trans. Numer. Anal. **17** (2004), 133–150 (electronic).

Kendall Atkinson and Weimin Han, *On the numerical solution of some semilinear elliptic problems*, Electron. Trans. Numer. Anal. **17** (2004), 206–217 (electronic).

Recommended resources in numerical analysis, in *Using the mathematics literature* (K. Fowler, ed.), Dekker, New York, 2004, pp. 273–299.

2005

Kendall Atkinson and Alvise Sommariva, *Quadrature over the sphere*, Electron. Trans. Numer. Anal. **20** (2005), 104–118 (electronic).

Kendall E. Atkinson and Alvise Sommariva, *On the numerical solution of some semilinear elliptic problems*–II, Computing **74** (2005), 159–175.

Kendall Atkinson and Olaf Hanson, *Solving the nonlinear Poisson equation in the unit disk*, J. Integral Equations Appl. **17** (2005), 223–241.

To appear

Jaehoon Seol and Kendall Atkinson, *Analytic evaluation of collocation integrals for the radiosity equation*, Appl. Numer. Anal. Comp. Math., to appear.

5. Doctoral students of Kendall Atkinson. Ken Atkinson supervised the doctoral dissertation research of 15 students, all at the University of Iowa. The names of these mathematicians and the year in which their Ph.D. degree was granted are as follows:

James Logan	1976	Robert Doucette	1991
Clayton Miller	1979	Young-Mok Jeon	1992
Pedro Cubillos	1980	Edwin Hardee	1993
Tzu-Chu Lin	1982	Yajun Yang	1993
Daniel Willis	1986	Yan Chen	1994
Jorge Saavedra	1988	Sanda Micula	1997
Jose Flores	1990	Jaehoon Seol	2002
David Chien	1991		

C.W. Groetsch
Dept. of Mathematical Sciences
University Of Cincinnati
Cincinnati, Ohio 45221-0025
E-mail: groetsch@uc.edu

M.Z. Nashed
Dept. of Mathematical Sciences
University Of Central Florida
Orlando, Florida 32816-1364
E-mail: znashed@mail.ucf.edu