Mark Ainsworth
Professor of Applied Mathematics

Publications

Monographs

[1] M. AINSWORTH AND J. ODEN, *A posteriori error estimation in finite element analysis*, Pure and Applied Mathematics,Wiley-Interscience, JohnWiley & Sons, New York, 2000.

Publications in Refereed Journals

[1] M. AINSWORTH, *The performance of Bank-Weiser's error estimator for quadrilateral finite elements*, Numer. Meth. PDE., 10 (1994), pp. 609–623.

[2] *Hierarchical domain decomposition preconditioner for h-p finite element approximation on locally refined meshes*, SIAM J. Sci. Comp., 17 (1996), pp. 1395–1413.

[3] *The influence and selection of subspaces for a posteriori error estimators*, Numer. Math., 73 (1996), pp. 399–418.

[4] *A preconditioner based on domain decomposition for h-p finite element approximation on quasi-uniform meshes*, SIAM J. Numer. Anal., 33 (1996), pp. 1358–1376.

[5] *A posteriori error estimators for fully discrete hierarchical modelling on thin domains.*, Numer. Math., 80 (1998), pp. 325–362.

[6] *Identification and a posteriori estimation of pollution errors in finite element analysis*, Comput. Methods Appl. Mech. Engrg., 176 (1999), pp. 3–17.

[7] *Essential boundary conditions and multi-point constraints in finite element analysis*, Comput. Methods Appl. Mech. Engrg., 190 (2001), pp. 6323–6339.

[8] *Discrete dispersion relation for hp-version finite element approximation at high wave number*, SIAM J. Numer. Anal., 42 (2004), pp. 553–575.

[9] *Dispersive and dissipative behaviour of high order discontinuous Galerkin finite element methods*, J. Comput. Phys.,198 (2004), pp. 106–130.

[10] *Dispersive properties of high order Nédélec/edge element approximation of the time-harmonic Maxwell equations*, Phil. Trans. Roy. Soc. Series A, 362 (2004), pp. 471–491.

[11] *A posteriori error estimation for non-conforming quadrilateral finite elements*, Int. J.Numer.Anal.Model., 2 (2005), pp. 1–18.

[12] *Robust a posteriori error estimation for nonconforming finite element approximation*, SIAM J. Numer. Anal., 42 (2005), pp. 2320–2341 (electronic).

[13] *A synthesis of a posteriori error estimation techniques for conforming, non-conforming and discontinuous Galerkin finite element methods*, Contemp. Math., 383 (2005), pp. 1–14.

[14] *"A posteriori error estimation for non-conforming quadrilateral finite elements" [Int. J.Numer. Anal.Model.* **2** *(2005),no. 1, 1–18; mr2112654]*, Int. J. Numer. Anal. Model., 4 (2007), pp. 141–142.

[15] *A posteriori error estimation for a discontinuous Galerkin finite element method*, SIAM J. Numer. Anal., 45 (2007), pp. 1777–1798.

[16] *A posteriori error estimation for lowest order Raviart-Thomas mixed finite elements*, SIAM J. Sci. Comp., 30 (2007/08), pp. 189–204.

[17] *A framework for obtaining guaranteed error bounds for finite element approximations*, J. Comput. Appl.Math., 234 (2010), pp. 2618 – 2632.

[18] M. AINSWORTH, A. ALLENDES, G. BARRENECHEA, AND R. RANKIN, *Computable error bounds for nonconforming fortin-soulie finite element approximation of the stokes problem*, IMA J. Numer. Anal., (Accepted for publication).

[19] M. AINSWORTH, G. ANDRIAMARO, AND O. DAVYDOV, *Bernstein-Bézier FEMand optimal assembly algorithms*, SIAM J. Sci. Comp., (Accepted for publication).

[20] M. AINSWORTH AND M. ARNOLD, *Construction and analysis of optimal hierarchic models of boundary value problems on thin circular and spherical geometries*, SIAM J. Sci. Comp., 22 (2000), pp. 673–703.

[21] *Computable error bounds for some simple dimensionally reduced models on thin domains*, IMA J. Numer. Anal., 21 (2001), pp. 81–105.

[22] M. AINSWORTH AND I. BABUŠKA, *Reliable and robust a posteriori error estimation for singularly perturbed reaction diffusion problems*, SIAM J. Numer. Anal., 36 (1999), pp. 331–353.

[23] M. AINSWORTH AND P. COGGINS, *The stability of mixed hp-finite element methods for Stokes flow on high aspect ratio elements*, SIAM J. Numer. Anal., 38 (2000), pp. 1721–1761.

[24] *A uniformly stable family of mixed hp-finite elements with continuous pressures for incompressible flow*, IMA J.Numer. Anal., 22 (2002), pp. 307–327.

[25] M. AINSWORTH AND J. COYLE, *Hierarchic hp-edge element families for Maxwell's equations on hybrid quadrilateral/triangular meshes*, Comput. Methods Appl. Mech. Engrg., 190 (2001), pp. 6709–6733.

[26] *Conditioning of hierarchic p-version Nedelec element on meshes of curvilinear quadrilaterals and hexahedra*, SIAM J. Numer. Anal., 41 (2003), pp. 731–750.

[27] *Hierarchic finite element bases on unstructured tetrahedral meshes*, Internat. J.Numer.Methods Engrg., 58 (2003), pp. 2103–2130.

[28] M. AINSWORTH, J. COYLE, P. LEDGER, AND K. MORGAN, *Computation of Maxwell eigenvalues using higher orderedge elements in three dimensions*, IEEE Trans. on Magnetics, 39 (2003), pp. 2149–2153.

[29] M. AINSWORTH AND A. CRAIG, *A posteriori error estimators in the finite element method*, Numer. Math., 60 (1991), pp. 429–463.

[30] M. AINSWORTH AND L. DEMKOWICZ, *Explicit polynomial preserving trace liftings on a triangle*, Math. Nachr., 282 (2009), pp. 640–658.

[31] M. AINSWORTH, L. DEMKOWICZ, AND C.-W. KIM, *Analysis of the equilibrated residual method for a posteriori error estimation on meshes with hanging nodes*, Comput. Methods Appl. Mech. Engrg., 196 (2007), pp. 3493–3507.

[32] M. AINSWORTH AND W. DÖRFLER, *Fundamental systems of numerical schemes for linear convection-diffusion equations and their relationship to accuracy*, Computing, 66 (2001), pp. 199–229.

[33] M. AINSWORTH, R. GRIGORIEFF, AND I. SLOAN, *Semi-discrete Galerkin approximation of the single layer equation by general splines*, Numer. Math., 79 (1998), pp. 157–174.

[34] M. AINSWORTH AND B. GUO, *An additive Schwarz preconditioner for p-version boundary element approximation of the hypersingular operator in three dimensions*, Numer. Math., 85 (2000), pp. 343–366.

[35] *Analysis of iterative sub-structuring techniques for boundary element approximation of the hypersingular operator in three dimensions*, Applicable Anal., 81 (2002), pp. 241–280.

[36] M. AINSWORTH AND D. KAY, *The approximation theory for the p-version finite element method and application to nonlinear elliptic PDEs*, Numer. Math., 83 (1999), pp. 351–388.

[37] *Approximation theory for the hp-version finite element method and application to the non-linear Laplacian*, Appl. Numer. Math., 34 (2000), pp. 329–344.

[38] M. AINSWORTH AND D. KELLY, *A posteriori error estimators and adaptivity for finite element approximation of the nonhomogeneous dirichlet problem*, Adv. Comp. Math., 15 (2001), pp. 3–23.

[39] M. AINSWORTH, D. KELLY, I. SLOAN, AND S. WANG, *Post processing with computable error bounds for finite element approximation*

of a non-linear heat conduction problem, IMA J. Numer. Anal., 17 (1997), pp. 547–561.

[40] M. AINSWORTH ANDW. MCLEAN,*Multilevel diagonal scaling preconditioners for boundary element equations on locally refined meshes*, Numer. Math., 93 (2003), pp. 387–413.

[41] M. AINSWORTH,W. MCLEAN, AND T. TRAN, *The conditioning of boundary element equations on locally refined meshes and preconditioning by diagonal scaling*, SIAM J. Numer. Anal., 36 (1999), pp. 1901–1932.

[42] *Diagonal scaling of stiffnessmatrices in the galerkin boundary element method*, ANZIAMJ., 42 (2000), pp. 141–150.

[43] M. AINSWORTH AND L. A. MIHAI, *A comparison of solvers for linear complementarity problems arising from large-scale masonry structures*, Appl. Math., 51 (2006), pp. 93–128.

[44] *Modelling and numerical analysis of masonry structures*, Numer. Meth. PDE., 23 (2007), pp. 798–816.

[45] *An adaptive multi-scale approach to the modelling of masonry structures*, Internat. J. Numer. Methods Engrg., 78 (2009), pp. 1135–1163.

[46] M. AINSWORTH, P. MONK, AND W. MUNIZ, *Dispersive and dissipative properties of discontinuous galerkin finite element methods for the second-order wave equation*, J. Sci. Comp., 27 (2006), pp. 5–40.

[47] M. AINSWORTH, J. ODEN, AND C. LEE, *Local a posteriori error estimators for variational inequalities*, Numer. Meth. PDE., 9 (1993), pp. 23–33.

[48] M. AINSWORTH, J. ODEN, AND W. WU, *A posteriori error estimators for h-p finite element approximations in linear elastostatics*, Appl. Numer. Math., 14 (1994), pp. 23–54.

[49] M. AINSWORTH AND J. T. ODEN, *A procedure for a posteriori error estimation for h–p finite element methods*, Comput. Methods Appl. Mech. Engrg., 101 (1992), pp. 73–96.

[50] *A posteriori error estimators for second order elliptic systems. Part 1. theoretical foundations and a posteriori error analysis*, Comput. Math. Appl., 25 (1993), pp. 101–113.

[51] *A posteriori error estimators for second order elliptic systems. Part 2. an optimal order process for calculating self equilibrating fluxes*, Comput. Math. Appl., 26 (1993), pp. 75–87.

[52] *A unified approach to a posteriori error estimation based on element residual methods*, Numer. Math., 65 (1993), pp. 23–50.

[53] *A posteriori error estimates for Stokes' and Oseen's equations*, SIAM J. Numer. Anal., 34 (1997), pp. 228–245.

[54] *A posteriori error estimation in finite element analysis*, omput.Methods Appl.Mech. Engrg., 142 (1997), pp. 1–88.

[55] M. AINSWORTH AND K. PINCHEDEZ, *hp-approximation theory for BDFM and RT finite elements on quadrilaterals*, SIAM J. Numer. Anal., 40 (2002), pp. 2047–2068 (electronic) (2003).

[56] *The hp-MITC finite element method for the Reissner-Mindlin plate problem*, J. Comput. Appl. Math., 148 (2002), pp. 429–462.

[57] M. AINSWORTH AND R. RANKIN, *Fully computable bounds for the error in nonconforming finite element approximations of arbitrary order on triangular elements*, SIAM J. Numer. Anal., 46 (2008), pp. 3207–3232.

[58] *Robust a posteriori error estimation for the nonconforming Fortin-Soulie finite element approximation*,Math. Comp., 77 (2008), pp. 1917–1939.

[59] *Fully computable error bounds for discontinuous Galerkin finite element approximations on meshes with an arbitrary number of levels of hanging nodes*, SIAM J. Numer. Anal., 47 (2010), pp. 4112–4141.

[60] *Guaranteed computable error bounds for conforming and nonconforming finite element analyses in planar elasticity*, Internat. J. Numer. Methods Engrg., 82 (2010), pp. 1114–1157.

[61] *Constant free error bounds for nonuniform order discontinuous Galerkin finite-element approximation on locally refined meshes with hanging nodes*, IMA J. Numer. Anal., 31 (2011), pp. 254–280.

[62] *A note on the selection of the penalty parameter for discontinuous Galerkin finite element schemes*, Numer. Meth. PDE., (Accepted for publication).

[63] M. AINSWORTH AND R. RANKIN, *Realistic computable error bounds for three dimensional finite element analyses inlinear elasticity*, Comput. Methods Appl. Mech. Engrg., (Accepted for publication).

[64] M. AINSWORTH AND B. SENIOR, *An adaptive refinement strategy for hp-finite element computations*, Appl. Numer. Math., 26 (1997), pp. 165–178.

[65] *Aspects of an adaptive hp-finite element method: Adaptive strategy, conforming approximation and efficient solvers*, Comput. Methods Appl. Mech. Engrg., 150 (1997), pp. 65–87.

[66] M. AINSWORTH AND S. SHERWIN, *Domain decomposition preconditioners for p and hp finite element approximation of Stokes equations*, Comput. Methods Appl. Mech. Engrg., 175 (1999), pp. 243–266.

[67] *Unsteady Navier-Stokes solvers using hybrid spectral/hp element methods.*, Appl. Numer. Math., 33 (2000), pp. 357–363.

[68] M. AINSWORTH AND T. VEJCHODSKY, *Fully computable robust a posteriori error bounds for singularly perturbed reaction-diffusion problems*, Numer. Math., (Accepted for publication).

[69] M. AINSWORTH AND H. A. WAJID, *Dispersive and dissipative behavior of the spectral element method*, SIAM J. Numer. Anal., 47 (2009), pp. 3910–3937.

[70] *Optimally blended spectral-finite element scheme for wave propagation and nonstandard reduced integration*, SIAM J. Numer. Anal., 48 (2010), pp. 346–371.

[71] M. AINSWORTH, J. ZHU, A. CRAIG, AND O. ZIENKIEWICZ,*Analysis of the Zienkiewicz Zhu a posteriori error estimator in the finite element method*, Internat. J. Numer. Methods Engrg., 28 (1989), pp. 2161–2174.

[72] A. CRAIG, M. AINSWORTH, J. ZHU, AND O. ZIENKIEWICZ, *h and h − p version error estimation and adaptive procedures from theory to practice*, Engineering with Computers, 5 (1989), pp. 221–234.

[73] L. DEMKOWICZ, J. ODEN, M. AINSWORTH, AND P. GENG, *Solution of acoustical scattering problems using h-p boundary element methods*, J. Comput. Appl. Math., 36 (1991), pp. 29–63.

[74] W. DÖRFLER AND M. AINSWORTH, *Reliable a posteriori error control for nonconformal finite element approximation of Stokes flow*, Math. Comp., 74 (2005), pp. 1599–1619 (electronic).

[75] L. A. MIHAI AND M. AINSWORTH, *An adaptive multi-scale computational modelling of Clare College Bridge*, Comput. Methods Appl. Mech. Engrg., 198 (2009), pp. 1839–1847.

[76] *A finite element procedure for rigorous numerical enclosures on the limit load in the analysis of multibody structures*, Comput. Methods Appl. Mech. Engrg., 199 (2009), pp. 48–60.

[77] J. ODEN, W. WU, AND M. AINSWORTH, *A posteriori error estimators for the Navier-Stokes problem*, Comput.Methods Appl. Mech. Engrg., 111 (1994), pp. 185–202.

Submitted for Publication

[1] M. AINSWORTH, A. ALLENDES, G. BARRENECHEA, AND R. RANKIN, *On the adaptive selection of the parameter in stabilized finite element approximations*, SIAM J. Numer. Anal., (Submitted for publication).

[2] M. AINSWORTH AND X. MA, *Non-uniform order mixed finite element approximation: implementation, post-processing, computable error bounds and adaptivity*, (Submitted for publication).

Edited Volumes

[1] M. AINSWORTH, P. DAVIES, D. DUNCAN, P. MARTIN, AND B. RYNNE, eds., *Topics in Computational Wave Propagation: Direct and Inverse Problems*, vol. 31 of Lecture Notes in Computational Science and Engineering, Heidelberg, 2003, Springer-Verlag.

[2] M. AINSWORTH, J. LEVESLEY,W. LIGHT, AND M. MARLETTA, *Differential Equations: Theory and Numerics*, Advances in Numerical Analysis IV, Oxford University Press, 1996.

[3] *Wavelets, Multilevel Methods and Elliptic PDEs*, Advances in Numerical Analysis V, Oxford University Press, 1997.

[4] M. AINSWORTH, J. LEVESLEY, AND M. MARLETTA, *The Graduate Student's Guide to Numerical Analysis '98*, vol. 26 of Springer Series in Computational Mathematics, Springer-Verlag, 1999.

Published Reviews

[1] M. AINSWORTH, *Review of "A posteriori error estimation and adaptive mesh refinement techniques" by R. Verfurth*, SIAM Rev., 40 (1998), pp. 391–392.

[2] *Review of "Verification and validation in computational science and engineering" by P.J. Roache*, SIAM Rev., 41 (1999), pp. 825–826.

[3] *Review of "p- and hp-Finite ElementMethods: Theory and Applications in Solid and FluidMechanics" by Ch. Schwab*, Math. Comp., 70 (2001), pp. 1335–1337.

[4] , *Review of "Adaptive finite element methods for differential equations" byW. Bangerth and R. Rannacher*, SIAM Rev., 46 (2004), pp. 354–356.

Conference Articles

[1] M. AINSWORTH, *A posteriori error estimation for smooth and non-smooth problems*, in Mathematics of Finite Elements and Applications VII, J.Whiteman, ed.,Wiley, London, 1991, pp. 85–92.

[2] *A posteriori error estimates for Stokes and Navier Stokes equations*, in Mathematics of Finite Elements and Applications VIII, J.Whiteman, ed.,Wiley, London, 1993.

[3] *Dispersive properties of high order finite elements*, inMathematical and Numerical Aspects of Wave Propagation WAVES2003. Proceedings of The Sixth International Conference onMathematical and Numerical Aspects of Wave Propagation, Jyväskylä, Finland, 30 June-4 July 2003, G. Cohen, E. Heikkola, P. Joly, and P. Neittaanmäki, eds., Heidelberg, 2003, Springer-Verlag, pp. 3–11.

[4] *Dispersive effects of discontinuous Galerkin fem for acoustics*, in Recent Progress in Scientific Computing,W. Liu, M. Ng, and Z.-C. Shi, eds., Beijing, 2007, Science Press, pp. 1–13.

[5] M. AINSWORTH AND M. ARNOLD, *A reliable a posteriori error estimator for adaptive hierarchic modelling*, in Advances in Adaptive Computational Methods in Mechanics, P. Ladeveze and J. Oden, eds., vol. 47 of Studies in Applied Mechanics, Elsevier, North-Holland, 1998, pp. 101–115.

[6] M. AINSWORTH, C. CARSTENSEN, AND W. DÖRFLER, *Mini-workshop: Convergence of Adaptive Algorithms*, Oberwolfach Rep., 2 (2005), pp. 2091–2138. Abstracts from the mini-workshop held August 14–20, 2005, Organized by Mark Ainsworth, Carsten Carstensen and Willy Dörfler, Oberwolfach Reports. Vol. 2, no. 3.

[7] M. AINSWORTH, P. COGGINS, AND B. SENIOR,*Mixed hp finite element methods for incompressible flow*, in Numerical Analysis 1999, D. Griffiths and G.Watson, eds., vol. 420 of Research Notes in Mathematics, Chapman &Hall/CRC, 2000, pp. 1–21.

[8] M. AINSWORTH AND J. COYLE, *Computation of Maxwell eigenvalues on curvilinear domains using hp-Nédélec elements*, in Numerical Mathematics and Advanced Applications, F. Brezzi, A. Buffa, S. Corsaro, and A.Murli, eds.,Milano, 2003, ENUMATH, Springer-Verlag Italia, pp. 219–231.

[9] M. AINSWORTH, J. COYLE, O. HASSAN, P. LEDGER, K. MORGAN, AND N. WEATHERILL, *hp-finite element approximation of Maxwell's*

equations on curvilinear hybrid meshes, in Proceedings of Second European Conference on Computational Mechanics, Cracow Poland., 2001.

[10] *Hybrid arbitrary order edge based finite element methods for electromagnetic scattering problems*, in Proceedings of the 17th ACES Conference. Monterey CA, 2001.

[11] M. AINSWORTH AND D. KAY, *The rate of convergence of the p-version finite element method for the non-linear Laplacian*,in Proceedings of the Prague Mathematical Conference 1996, K. S. et al., ed., Icaris, Czech Republik, 1996, pp. 1–5.

[12] M. AINSWORTH AND H. MELBOE, *A posteriori error estimation for high aspect ratio finite elements*, in Proceedings of Second European Conference on Computational Mechanics, Cracow Poland, 2001.

[13] M. AINSWORTH AND B. SENIOR, *hp-finite element procedures on non-uniform geometric meshes: adaptivity and constrained approximation*, in Grid generation and adaptive algorithms (Minneapolis, MN, 1997), vol. 113 of IMA Vol. Math. Appl., Springer, New York, 1999, pp. 1–27.

[14] M. AINSWORTH, B. SENIOR, AND D. ANDREWS, *Preconditioners for the adaptive h-p version finite element method*, in The Mathematics of Finite Elements and Applications, J.Whiteman, ed., John Wiley & Sons, 1997, pp. 81–91.

[15] M. AINSWORTH AND H. A. WAJID, *Explicit discrete dispersion relations for acoustic wave equation in d-dimensions using finite element, spectral element and optimally blended schemes*, in Computer Methods in Mechanics, M. Kuczma and K. Wilmanski, eds., Advanced Structured Materials, Springer, Berlin Heidelberg, 2010, ch. 1, pp. 3–19.

[16] T. CAO, D. KELLY, AND M. AINSWORTH, *Some useful techniques for pointwise and local error estimates of the quantities of interest in finite element approximation*, ANZIAM J., 42 (2000), pp. C317–C339.

[17] C. LEE, J. ODEN, AND M. AINSWORTH, *Local a posteriori error estimates and numerical results for contact problems and problems of flow*

through porous media, in Nonlinear Computational Mechanics - State of the Art, Springer, 1991.

[18] J. ODEN, W. WU, AND M. AINSWORTH, *Three step h-p adaptive strategy for the incompressible Navier Stokes equations*, in Modeling, Mesh Generation and Adaptive Numerical Methods for Partial Differential Equations, I. Babuska and J. Flaherty, eds., IMA Minnesota, 1995.

[19] O. ZIENKIEWICZ, J. ZHU, A. CRAIG, AND M. AINSWORTH, *Simple and practical error estimation and adaptivity h and h-p version procedures*, in Adaptive Methods for Partial Differential Equations, J. F. et al, ed., SIAM, 1989, pp. 100–115.