KONSTANTIN N. LIPNIKOV

Curriculum Vitae

Business Address:

Los Alamos National Laboratory
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Education:

Ph.D.	Mathematics, University of Houston, May 2002 Thesis: *Numerical Methods for the Biot Model in Poroelasticity* Adviser: *Yuri A. Kuznetsov*
M.S.	Mathematics, University of Houston, Fall 2000, GPA 3.94/4.00
M.S.	Applied Mathematics, Moscow Institute of Physics and Technology, 1990, Moscow Region, RUSSIA

Employment History:

01/2005 – *present*	*Research Staff Member* Mathematical Modeling and Analysis Group, Theoretical Division Los Alamos National Laboratory, Los Alamos, NM
06/2002 – 12/2004	*Postdoctoral Research Associate* Mathematical Modeling and Analysis Group, Theoretical Division Los Alamos National Laboratory, Los Alamos, NM
06/2001 – 08/2001	*Graduate Research Assistant* Mathematical Modeling and Analysis Group, Theoretical Division Los Alamos National Laboratory, Los Alamos, NM
09/2000 – 05/2002	*Research Assistant* Department of Mathematics, University of Houston, Houston, TX
06/2000 – 07/2000	*Graduate Research Assistant* Computational Fluid Dynamics Laboratory, University of Texas, Austin, TX
01/1999 – 05/2000	*Research Assistant/Teaching Assistant* Department of Mathematics, University of Houston, Houston, TX
09/1993 – 01/1999	*Research Staff Member* Institute of Numerical Mathematics, Moscow, RUSSIA
09/1990 – 07/1993	*Research Assistant* Moscow Institute of Physics and Technology, Moscow, RUSSIA

Revised: July 2008

Research Experience:

2002 – *present* — *Postdoc/Research Staff Member*, Mathematical Modeling and Analysis Group, Los Alamos National Laboratory. I have developed new mimetic finite difference discretization methods that are effective for diffusion problems with highly discontinuous coefficients on severely distorted polyhedral grids. Recently, this research has been used to develop new artificial viscosity methods for gasdynamics and has generated an interest in developing similar mimetic discretizations for problems in seismology (analysis of elastic waves scattering in heterogeneous media), in fluid dynamics (analysis of transport of pollutant from streams and rivers into underground water reservoirs), and in electromagnetics. I'm also continuing to develop robust moving mesh methods for gasdynamics that capture the solution dynamics and therefore increase accuracy of computer simulations.

1999 – 2001 — *Ph.D. research*, Department of Mathematics, University of Houston. I conducted research on numerical methods for solving the system of partial differential equations describing two basic mechanical processes in porous media: single-phase fluid flow and rock deformation. The research was supported in part by a few grants from the Exxon-Mobil Upstream Research Company.

2001 (Summer) — *Visitor/Graduate Research Assistant*, Mathematical Modeling and Analysis Group, Los Alamos National Laboratory. During my Ph.D. studies, I began collaboration on analysis of key aspects of the support operator methods that were developed at LANL and were used in several codes. In particular, I gave the first proof of convergence of these methods. It marked the beginning of an exciting new approach to creating new discretization methods.

2000 (Summer) — *Visitor/Graduate Research Assistant*, Computational Fluid Dynamics Laboratory, University of Texas, Austin, TX. I collaborated with Prof. Graham Carey on extending the cascadic multigrid methods for solving a nonlinear problem coupling flow of a viscous incompressible fluid with heat transfer and chemical species transport.

1993 – 1999 — *Staff Member*, Institute of Numerical Mathematics, Moscow, Russia. I worked on developing memory-saving numerical methods for the problem of scattering acoustic waves by an impenetrable obstacle. The developed method were used by my colleagues to solve 100 times large problems that it was possible with the other methods.

1998 (Fall) — *Visiting Researcher*, Konrad-Zuse-Zentrum Berlin, Berlin, Germany. I developed and analyzed the cascadic multigrid method for elliptic problems with strong material discontinuities and proved its convergence for mortar finite element discretizations.

1998 (Summer) *Visiting Researcher*, Scientific Center, Dassault-Aviation, Paris, France. I investigated a new mathematical model for thin dielectric layers over an ideal conductor. Different properties of the dielectric were exploited via numerical experiments to characterize their impact on the far-field pattern of a scattered time-harmonic electromagnetic wave.

1996 (Spring) *Visiting Researcher*, Seoul National University, Seoul, South Korea. I analyzed an inverse acoustic problem of recovering the shape of an obstacle from the scattered wave pattern. It was shown that the regularized inverse problem allows reasonable obstacle reconstruction even in the presence of white noise in the input data.

1995 (Spring) *Visiting Researcher*, University of Neimegen, Neimegen, The Netherlands. Using the Cray Y-MP C98 supercomputer system, I studied efficient implementation of the fictitious domain method and the domain decomposition method for solving the exterior boundary value problem for the Helmholtz wave equation.

1994 (Summer) *Visiting Researcher*, University of Paris VI, Paris, France. I designed and conducted numerical experiments to study the scattering of acoustic waves by model obstacles resembling aircrafts. The success of this research was crucial for expanding the cooperation program with french colleagues.

Publications (1996-2008):

Invited:

1. A new discretization methodology for diffusion problems on generalized polyhedral meshes, *Comput. Methods Appl. Mech. Engrg.*, **196** (2007), 3682–3692 (with F.Brezzi, M.Shashkov and V.Simoncini).

2. On discrete boundaries and solution accuracy in anisotropic adaptive meshing. *Engrg. Computers*, (2007), accepted (with Yu.Vassilevski).

3. The error-minimization-based strategy for moving mesh methods. *Communications in Computational Physics*, **1**:1 (2006), 53–81 (with M.Shashkov).

4. Hessian recovery method for adaptive mesh generation, *Voprosy Atomnoj Nauki i Tehniki.* Ser. "Mathematical modeling of physical processes", **3** (2006), 37–53 (with Yu.Vassilevski).

5. A node reconnection algorithm for mimetic finite difference discretizations of elliptic equations on triangular meshes, *Communications in Mathematical Sciences*, **3**:4 (2005), 665–680 (with M.Berndt, M.Shashkov and P.Vachal).

6. Hessian based anisotropic mesh adaptation in domains with discrete boundaries, *Russian J. Numer. Analysis Math. Modelling*, **20**, No.4 (2005), 391–402 (with V.Dyadechko and Yu.Vassilevski).

7. On control of adaptation in parallel mesh generation, *Engineering with Computers*, **20** (2004), 193–201 (with Yu.Vassilevski).

Peer-Reviewed:

8. High-order mimetic finite difference method for diffusion problems on polygonal meshes, to appear in *J. Comp. Physics* (with V.Gyrya).

9. A multilevel multiscale mimetic (M^3) method for two-phase flows in porous media, *J. Comp. Physics* **144** (2008), 6727-6753. (with D.Moulton and D.Svyatskiy).

10. Monotone finite volume schemes for diffusion equations on unstructured triangular and shape-regular polygonal meshes, *J. Comp. Physics* **227** (2007), 492-512 (with M.Shashkov, D.Svyatskiy and Yu.Vassilevski).

11. Convergence of mimetic finite difference method for diffusion problems on polyhedral meshes with curved faces, *M3AS: Mathematical Models and Methods in Applied Sciences*, **16**:2 (2006), 275–297 (with F.Brezzi and M.Shashkov).

12. The error-minimization-based rezone strategy for arbitrary Lagrangian-Eulerian methods, *Numerical Methods for PDEs* **22**:3 (2006), 617-637 (with M.Shashkov).

13. The mimetic finite difference discretization of diffusion problem on unstructured polyhedral meshes, *J. Comp. Phys.* **211** (2006), 473–491 (with M.Shashkov and D.Svyatskiy).

14. Convergence of mimetic finite difference method for diffusion problems on polyhedral meshes, *SIAM J. Numer. Anal.* **43**:5 (2005), 1872–1896 (with F.Brezzi and M.Shashkov).

15. Error bounds for controllable adaptive algorithms based on a Hessian recovery, *Computational Mathematics and Mathematical Physics*, **45**:8 (2005), 1424–1434 (with Yu.Vassilevski).

16. A family of mimetic finite difference methods on polygonal and polyhedral meshes, *M3AS: Mathematical Models and Methods in Applied Sciences* **15**:10 (2005), 1533–1552 (with F.Brezzi and V.Simoncini).

17. A mortar mimetic finite difference method on non-matching grids, *Numer. Math.*, **102**:2 (2005), 203–230 (with M.Berndt, M.Shashkov, M.Wheeler and I.Yotov).

18. Superconvergence of the velocity in mimetic finite difference methods on quadrilaterals, *SIAM J. Numer. Anal.* **43**:4 (2005), 1728–1749 (with M.Berndt, M.Shashkov, M.Wheeler and I.Yotov).

19. Mimetic finite difference method on polygonal meshes for diffusion-type problems, *Comp. Geosciences*, **8** (2004), 301–324 (with Yu.Kuznetsov and M.Shashkov).

20. Mimetic finite difference methods for diffusion equations on non-orthogonal non-conformal meshes. *J. Comp. Phys.*, **199** (2004), 589–597 (with J.Morel and M.Shashkov).

21. Mathematics modeling and numerical algorithms for poroelastic problems, *Contemporary Mathematics*, **329** (2003), 191–202 (with Yu.Kuznetsov, S.Lyons and S.Maliassov).

22. Optimal triangulations: existence, approximation and double differentiation of P_1 finite element functions, *Computational Mathematics and Mathematical Physics*, **43**:6 (2003), 827–835 (with Yu.Vassilevski).

23. Nested grid iteration for incompressible viscous flow and transport, *Inter. J. Comp. Fluid Dynamics*, **17**:4 (2003), 253–262 (with G.Carey and B.Kirk).

24. Parallel adaptive solution of 3D boundary value problems by Hessian recovery, *Comput. Methods Appl. Mech. Engrg.*, **192** (2003), 1495–1513 (with Yu.Vassilevski).

25. A subspace cascadic multigrid method for mortar elements, *Computing*, **69**:3 (2002), 205–225 (with D.Braess and P.Deuflhard).

26. Fast separable solver for mixed finite element methods and applications, *J. Numer. Math.*, **10**:2 (2002), 137–155 (with Yu.Kuznetsov).

27. Convergence of mimetic finite difference discretizations of the diffusion equation, *East-West J. Numer. Math.*, **9**:4 (2001), 265–284 (with M.Berndt, D.Moulton and M.Shashkov).

28. An efficient iterative solver for a simplified poroelasticity problem, *East-West Journal*, **8**:3 (2000), 207–222 (with Yu.Kuznetsov).

29. Adaptive generation of quasi-optimal tetrahedral meshes, *East-West Journal*, **7** (1999), 223–244 (with A.Agouzal and Yu.Vassilevski).

30. An adaptive algorithm for quasi-optimal mesh generation, *Computational Mathematics and Mathematical Physics*, **39** (1999), 1468–1486 (with Yu.Vassilevski).

31. Fictitious domain methods for the numerical solution of three-dimensional acoustic scattering problems, *J. Comp. Acoustics*, **7**:3 (1998), 161–183 (with E.Heikkola and Yu.Kuznetsov).

32. 3D Helmholtz wave equation by fictitious domain method, *Russian J. Numer. Anal. and Math. Modelling*, **13** (1998), 371–389 (with Yu.Kuznetsov).

33. Domain decomposition with subdomain CCG for material jump elliptic problems, *East-West Journal*, **6** (1998), 81–100 (with P.Deuflhard).

Under Review:

34. Interpolation-free monotone finite volume method for diffusion equations on polygonal meshes, submitted to *J. Comp. Phys.* (with D.Svyatskiy, and Yu.Vassilevski).

35. Error estimates for a finite element solution of the diffusion equation based on composite norms, submitted to *SIAM J. Numer. Anal.* (with A.Agouzal and Yu.Vassilevski).

36. Mimetic finite differences for elliptic problems, submitted to *M2AN: Math. Model. Numer. Anal.* (with F.Brezzi and A.Buffa).

37. Local flux mimetic finite difference methods, submitted to *Numerishe Mathematik* (with M.Shashkov and I.Yotov).

38. A new discretization scheme on polyhedral grids for diffusion problems, submitted to *SIAM J. Sci. Comp.* (with J.Morel and S.Runnels).

In Proceedings:

39. Mimetic finite difference method, Proceedings of *5th International Symposium on Finite Volumes for Complex Applications*, June 8-13, 2008, Aussois, France; R.Eymard, J.-M.Hérard (Editors), Wiley, pp.843–850.

40. Generation of quasi-optimal meshes based on a posteriori error estimates, Proceedings of *16th International Meshing Roundtable*, October 15-17, 2007, Seattle, WA. M.Brewer, D.Marcum (Editors), Springer, pp.139–148. (with A.Agouzal and Yu.Vassilevski).

41. Analysis of Hessian recovery methods for generating adaptive meshes, Proceedings of *15th International Meshing Roundtable*, September 17-20, 2006, Birmingham, LA. P.Pebay (Editor), Springer, pp.163–171. (with Yu.Vassilevski).

42. On discrete boundaries and solution accuracy in anisotropic adaptive meshing, Proceedings of *14th International Meshing Roundtable*, September 11-14, 2005, San Diego, CA. Byron W.Hanks (Editor), Springer, pp.313–324 (with Yu.Vassilevski).

43. Error estimates for Hessian-based mesh adaptation algorithms with control of adaptivity, Proceedings of *13th International Meshing Roundtable*, September 19-22, 2004, Williamsburg, Virginia, pp.345-351 (with Yu.Vassilevski).

44. On a parallel algorithm for controlled Hessian-based mesh adaptation, Proceedings of *3rd Conf. Appl. Geometry, Mesh Generation and High Performance Computing*, Moscow, June 28 – July 1, 2004, Comp. Center RAS, Vol.1, pp.154-166 (with Yu.Vassilevski).

45. Moving grids for hyperbolic problems, *Proceedings of the Workshop on Mesh Quality and Dynamic Meshing*, January 16-17, 2003, Sandia National Laboratory, Livermore, CA (with M.Shashkov).

46. Fictitious domain based solvers for particulate flows, *Proceedings of the 13th International Conference on DD Methods*, October 2000, Lyon, France, pp.351–357 (with D.Dashevski, R.Glowinski and Yu.Kuznetsov).

47. Finite element methods with nonmatching grids and applications, *Proceedings of the Conference on Applied Mathematics and Computer Science*, October 28-29, 1996, Moscow, French-Russian A.M.Liapunov Institute, Moscow State University, pp.65–81 (with G.Abdoulaev, Y.Achdou, Yu.Kuznetsov, J.Periaux and O.Pironneau).

Selected Technical Reports:

48. Metric-based control of mesh adaptation in arbitrary Lagrangian Eulerian simulations, Los Alamos Report LAUR-06-4765 (2006) (with Yu.Vassilevski).

49. Moving meshes for the Burgers equation, Los Alamos Report LAUR-03-7605 (2003) (with M.Shashkov).

50. On the application of fictitious domain and domain decomposition methods for scattering problems on Cray Y-MP C98, *Report No.9557*, University of Nijmegen, The Netherlands, 1998 (with Yu.Kuznetsov).

51. On using parallel MIMD computer systems in the inverse problem of acoustic scattering, *RIM–GARC Preprint Series 96-27*, Seoul National University, Seoul, South Korea, June 1996.

Scientific Presentations (2003-2008):

Invited:

1. *Mimetic finite difference method for PDEs*, CCMA PDEs and Numerical Methods Seminar Series, Department of Mathematics, PennState University, May 2008.

2. *Mimetic discretization methods*, Colloquium, Department of Mathematics, Oregon State University, March, 2008.

3. *Mimetic finite difference method for diffusion problems*, Applied Mathematics and Computation Seminar, Oregon State University, March, 2008.

4. *High order mimetic discretiations on finite volume meshes*, Lawrence Livermore National Laboratory, Livermore, December, 2007.

5. *Optimal and Quasi-Optimal Meshes for Numerical Solution of PDEs*, International Conference on Adaptive Modeling and Simulation, Goteborg, SWEDEN, October 2007.

6. *Second-order accurate discretization method for diffusion problems with tensor coefficients on polyhedral meshes*, Sandia National Laboratory, Albuquerque, NM, August 2007.

7. *Optimal and quasi-optimal meshes for numerical solution of PDEs*, Innovative Computing Laboratory, University of Tennessee, Knoxville TN, December 2006.

8. *The new error-minimization-based moving mesh method: theoretical and numerical analysis*, SIAM annual meeting, Boston, MA, July 2006.

9. *The error-minimization-based rezone strategy for arbitrary Lagrangian-Eulerian methods*, Seminar "Applied and Computational Mathematics", Tulane University, LA, January 2005.

10. *Mimetic finite difference methods on unstructured polyhedral meshes*, 8th US National Congress for Computational Mechanics, Austin, TX, July 2005.

11. *Convergence of mimetic finite difference discretizations for diffusion equations*, Workshop on Mimetic Discretizations of Continuum Mechanics, San Diego, CA, July 2003.

12. *Mimetic finite difference methods for diffusion equations on non-orthogonal AMR meshes*, Workshop on Mimetic Discretizations of Continuum Mechanics, San Diego, CA, July 2003.

Conferences:

13. *Generation of quasi-optimal meshes based on a posteriori error estimates*, 16th international Meshing Roundtable, Seattle, WA, October 2007.

14. *Mimetic finite difference methods on polyhedral meshes*, SIAM Conference on Mathematical and Computational Issues in the Geosciences, Santa Fe, NM, March 20, 2007.

15. *Mimetic finite difference methods on generalized polyhedral meshes*, NECDC–14th Joint Laboratory Biennial Conference, Los Alamos, NM, October 2006.

16. *Numerical analysis of Hessian recovery methods for generating adaptive meshes*, 15th International Meshing Roundtable, Birmingham, LA, September 2006.

17. *New discretization methodology for diffusion problems on generalized polyhedral meshes*, LACSI Symposium, Santa Fe, NM, October 2005.

18. *On discrete boundaries and solution accuracy in anisotropic adaptive meshing*, 14th International Meshing Roundtable, San Diego, CA, September 2005.

19. *A family of mimetic finite difference methods on polygonal and polyhedral meshes*, SIAM Annual Meeting, New Orleans, LA, July 2005.

20. *Convergence of mimetic finite difference method for diffusion problems on polyhedral meshes*, SIAM Conf. on Computational Science & Engineering, Orlando, FL, February 2005.

21. *Convergence of mimetic finite difference method for diffusion problems on polyhedral meshes*, LACSI Symposium, Santa Fe, NM, October 2004.

22. *Error estimates for Hessian-based mesh adaptation algorithms with control of adaptivity*, 13th International Meshing Roundtable, Williamsburg, VA, September 2004.

23. *The EMB rezone strategy for ALE methods*, SIAM annual meeting, Portland, OR, July 2004.

24. *Error-minimization-based rezone strategy for ALE methods*, 8th Copper Mountain Conference, Copper Mountain, CO, April 2004.

25. *Mimetic discretizations for diffusion equation on polygonal meshes in Cartesian and cylindrical geometries*, LACSI Symposium, Santa Fe, NM, October 2003.

26. *Moving grids for problems of gas dynamics*, 7th US National Congress on Computational Mechanics, Albuquerque, NM, July 2003.

27. *Robust parallel algorithm for anisotropic adaptive tetrahedral meshes*, 7th US National Congress on Computational Mechanics, Albuquerque, NM, July 2003.

28. *Algebraic multilevel preconditioner with projectors*, 11th Copper Mountain Conference, Copper Mountain, CO, April 2003.

29. *Mimetic finite difference methods for diffusion equations on AMR meshes*, SIAM Conference on Mathematical and Computational Issues in the Geosciences, Austin, TX, March 2003.

Miscaleneous:

30. *Mimetic Methods for Solving Diffusion Problems on Polyhedral Meshes*, ExxonMobil Upstream Research Company, Houston, TX, September 2007.

31. *Monotone Finite Volume Methods on Unstructured Triangular and Shape-Regular Polygonal Meshes*, ExxonMobil Upstream Research Company, Houston, TX, September 2007.

32. *A new discretization method for solving pressure equation on arbitrary meshes*, Los Alamos National Laboratory, September 2007.

Workshop Organization:

1. **Co-organizer:** *Adaptive anisotropic mesh generation: Advances in analysis and practice*, Minisymposium in the SIAM Conference on Mathematical and Computational Issues in the Geosciences, Avignon, France, June 7-10, 2005.

2. **Organizer:** *Moving mesh methods*, Minisymposium in the SIAM Annual Meeting, Portland, OR, July 12-16, 2004.

Panels:

1. *Panel Member*: "Research at Fundamental Scales" at Computational Subsurface Sciences Workshop, Washington DC, January 10-12, 2007.

2. *Committee Member:* Los Alamos National Laboratory, Laboratory-Directed Research and Development, Exploratory Research (LDRD/ER), *Mathematics and Computational Science*, 2006.

Journal Referee:

- Journal of Computational Physics
- SIAM Journal on Numerical Analysis
- SIAM Journal on Scientific Computing
- Numerical Methods for PDEs
- Communications in Computational Physics
- Transport in Porous Media
- Applied Numerical Mathematics
- Physics Letters A
- Discrete Applied Mathematics
- Computational Mathematics and Mathematical Physics
- IMA Journal of Numerical Analysis

The total number of reviewed manuscripts in 2003-2008 is 35.

Achievements and Awards:

01/2006	Achievement Award, Los Alamos National Laboratory *Outstanding contributions to the programmatic project.*
01/1984	The second place award in the regional olympiad of young mathematicians (region with about 80,000 high school students).

Academic Activities:

1. mentor of the postdoctoral researcher, Daniil Svyatskiy, 2006–2008
2. mentor of the summer student, Vitaliy Gyrya, 2007, 2008
3. mentor of the summer student, Danail Vassilev, 2006
4. mentor of the summer student, Daniil Svyatskiy, 2005
5. reviewer for "Mathematical Reviews"

Professional Memberships:

- Society of Industrial and Applied Mathematics (SIAM)
- American Mathematical Society (AMS)

Computing Experience:

- *Numerical Analysis:*
  I have 15 years of experience in developing algorithms for the numerical solution of partial differential equations. Knowledge of discretization techniques includes finite differences, finite elements, spectral elements, finite volume methods, etc. Knowledge of iterative solution techniques includes preconditioned Krylov subspace, multigrid and domain decomposition methods.
- *Programming:*
  Experience with many languages, including Fortran 90/95, Fortran 77, C, C++, MPI, Matlab, Maple, LaTeX, PostScript, HTML, XML. Currently working on two multi-developer projects using the concurrent versions system (CVS) and the version control system (SVN).

References:

Dr. James Hyman, Los Alamos National Laboratory, MS B284, Los Alamos NM, phone: (505) 667-6294, e-mail: hyman@lanl.gov

Prof. Dr. Yuri Kuznetsov, University of Houston, Department of Mathematics, Houston TX, phone: (713) 743-3493, e-mail: kuz@math.uh.edu