

## Alexander M. Balk

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### Education

Ph.D. (Mathematics and Physics) 1988

Moscow Institute of Physics and Technology;  
Landau Institute for Theoretical Physics,  
Russian Academy of Sciences  
Advisor – Professor *Vladimir E. Zakharov*

M.S. (Applied Mathematics) 1984

Moscow Institute of Physics and Technology;  
Computer Center, Russian Academy of Sciences  
Advisor – Professor *Nikita N. Moiseev*

### Academic Positions

*University of Utah, Department of Mathematics* (Salt Lake City, UT)

Professor, July 2006 — present  
Associate Professor, July 2000 — June 2006  
Assistant Professor, July 1996 — June 2000

*Institute for Advanced Study, School of Mathematics* (Princeton, NJ)

Member, September 2002 — June 2003

*California Institute of Technology* (Pasadena, CA)

Visiting Associate in Applied Mathematics, September — December 1996  
von Karman Instructor in Applied Mathematics, September 1993 — August 1996

*University of Arizona, Department of Mathematics* (Tucson, AZ)

Research Associate, January — June 1991, January 1992 — June 1993

*Landau Institute for Theoretical Physics* (Moscow, Russia)

Member, 1988 — 1998

## Invited Participation in Research Programs, Workshops, and Conferences

- Isaac Newton Institute* (Cambridge, UK); May 2024 (upcoming, accepted)  
Workshop “Climate Applications of Layering”
- Isaac Newton Institute* (Cambridge, UK); May 2022  
Workshop “Advances in geophysical and astrophysical turbulence”
- Institute for the Mathematical Sciences* (Madrid, Spain); 3-6 July 2012  
2-nd International Workshop “Nonlinear Processes in Oceanic and Atmospheric Flows”
- Aspen Center for Physics* (Aspen, CO); 10-24 June 2012  
Research Program “Stochastic Flows and Climate Modeling”
- Woods Hole Oceanographic Institution* (Woods Hole, Massachusetts); July 17-23, 2011  
Program on Geophysical Fluid Dynamics “Shear Turbulence: Onset and Structure”
- University of Arizona* (Tucson, AZ); 26-29 March 2010  
Conference “Frontiers in Nonlinear Waves”
- National Center for Atmospheric Research* (Boulder, Colorado); February 11-13, 2010  
Workshop “Mathematics of Interacting Climate Processes”
- Woods Hole Oceanographic Institution* (Woods Hole, Massachusetts); June-July (3 weeks) 2009  
Program on Geophysical Fluid Dynamics: “Nonlinear Waves”
- Banff International Research Station* (Banff, Canada); October 2008  
Workshop “Singular Phenomena in Nonlinear Optics, Hydrodynamics and Plasmas”
- Kavli Institute for Theoretical Physics*, University of California Santa Barbara; June-July (5 weeks) 2008  
Research Program “Physics of Climate Change”
- Aspen Center for Physics* (Aspen, CO); June-July (3 weeks) 2005  
Research Program “Novel Approaches to Climate”
- Institute for Advanced Study* (Princeton, NJ); March 2003  
Conference on Turbulence
- Isaac Newton Institute* (Cambridge, UK); August 2001  
Conference “Theoretical Developments: Two and Three Dimensional Water Waves”
- Stanford University* (Stanford, CA); July-August (3 weeks) 2000  
Mathematical Geophysics Summer School
- Joint AMS-IMS-SIAM summer research conference in Mathematical Sciences* (South Hadley, MA); June 2000  
“Dispersive wave turbulence”
- University of Arizona* (Tucson, AZ); October 1999  
Symposium in honor of Vladimir Zakharov’s 60-th birthday
- Centre National de la Recherche Scientifique* (Nice, France); May 1998  
IUTAM Symposium “The three-dimensional aspects of air-sea interaction”
- Tokyo Metropolitan University* (Tokyo, Japan); May 1994  
Conference on Dynamical Systems and Chaos
- NATO Advanced Study Institute* (Cargese, France); August 1993  
“Turbulence: Weak and Strong”
- Case Western Reserve University* (Cleveland, OH); June 1992  
CBMS-NSF Conference on Nonlinear Waves and Weak Turbulence
- Institute for Advanced Study* (Princeton, NJ); March 1992  
Workshop on Fluid Dynamics and Statistical Physics

## Bibliography

### Submitted and In-preparation Manuscripts

- [1] A. M. Balk, *Unidirectional turbulence of ocean waves*, in preparation (2023-2024).

### Refereed Publications

- [2] A. M. Balk, *Extra invariant and plasma inhomogeneity to improve zonal flow*, *Physics of Plasmas*, **31**, Issue 2 (2024) [published by AIP (American Institute of Physics)].
- [3] A. M. Balk, *Dynamo and the adiabatic invariant*, *ApJ (The Astrophysical Journal)*, **926** 2 (6pp) 2022.
- [4] A. M. Balk, *Poloidal flow generation in the dynamics of Rossby waves*, *Phys. Rev. Research* 1 (2019) 033180-(1:5).
- [5] A. M. Balk, *Mode generation via interaction*, *Phys. Rev. E* 98 (2018) 062208-(1:5).
- [6] A. M. Balk, *Rossby wave extra invariant in the Galerkin approximation*, *Phys. Lett. A* 381 (2017) 2510-2513.
- [7] A. M. Balk, *An extra invariant for the system of four wave packets in one spatial dimension*, *Wave Motion* **61** (2016) 11-19.
- [8] A. M. Balk, *Large-scale quasi-geostrophic magnetohydrodynamics*, *ApJ (The Astrophysical Journal)*, **796** (2014) 143 (8pp).
- [9] A. M. Balk, *The Rossby wave extra invariant in the dynamics of 3D fluid layers and the generation of zonal jets*, *Nonlin. Processes Geophys.* **21** (2014) 49-59.
- [10] A. M. Balk, F. van Heerden, and P. B. Weichman, *Rotating shallow water dynamics: Extra invariant and the formation of zonal jets*, *Phys. Rev. E* **83** (2011) 046320-(1-12).
- [11] A. M. Balk and V. E. Zakharov, *Cascade generation of zonal flows by the drift wave turbulence*, *Phys. Lett. A* **373** (2009) 4049-4052.
- [12] A. M. Balk and T. Yoshikawa, *The Rossby wave extra invariant in the physical space*, *Physica D: Nonlinear Phenomena* **238** (2009) 384-394.
- [13] A. M. Balk and F. van Heerden, *Conservation style of the extra invariant for Rossby waves*, *Physica D: Nonlinear Phenomena* **223** (2006) 109-120.
- [14] A. M. Balk, *Wave turbulent diffusion due to the Doppler shift*, *Journal of Statistical Mechanics: Theory and Experiment* P08018 (2006) 1-13.
- [15] A. M. Balk, *Angular distribution of Rossby wave energy*, *Phys. Lett. A* **345** (2005) 154-160.
- [16] A. M. Balk, G. Falkovich, and M. G. Stepanov, *Growth of density inhomogeneities in a flow of wave turbulence*, *Phys. Rev. Lett.* **92** (2004) 244504-(1-4).
- [17] A. M. Balk, *Propagation in multiscale media*, *Physica B* **338** (2003) 1-3.
- [18] T. Yoshikawa and A. M. Balk, *A conformal-mapping model for bubbles and fingers of the Rayleigh-Taylor instability*, *Math. and Computer Modeling* **38** (2003) 113-121.

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- [19] A. M. Balk, *Surface gravity wave turbulence: Three-wave interaction?* Phys. Lett. A **314** (2003) 68-71.
- [20] A. M. Balk, *Anomalous behavior of a passive tracer in wave turbulence*, J. Fluid Mech. **467** (2002) 163-203.
- [21] A. M. Balk, *Anomalous transport by wave turbulence*, in: “Advances in Wave Interaction and Turbulence”, Eds P. Milewski, L. Smith, E. Tabak, and F. Waleffe, *Contemporary Mathematics*, Vol. 283 (American Mathematical Society, Providence, RI, 2001), pp. 13-25.
- [22] A. M. Balk, A. V. Cherkhev, and L. I. Slepian, *Dynamics of chains with non-monotone stress-strain relations. I. Model and numerical experiments*, J. Mech. Phys. Solids, **49** (1) (2001) 131-148.
- [23] A. M. Balk, A. V. Cherkhev, and L. I. Slepian, *Dynamics of chains with non-monotone stress-strain relations. II. Nonlinear waves and waves of phase transition*, J. Mech. Phys. Solids, **49** (1) (2001) 149-171.
- [24] A. M. Balk, *Anomalous diffusion of a tracer advected by wave turbulence*, Phys. Lett. A **279** (2001) 370-378.
- [25] A. M. Balk, *On the Kolmogorov-Zakharov spectra of weak turbulence*, Physica D, **139** (2000) 137-157.
- [26] A. M. Balk, *Is the suppression of short waves by a swell a three-dimensional effect?*, Eur. J. Mech. B/Fluids **18** (1999) 429-432.
- [27] A. M. Balk and R. M. McLaughlin, *Passive scalar in a random wave field: The weak turbulence approach*, Phys. Lett. A **256** (1999) 299-306.
- [28] T. Yoshikawa and A. M. Balk, *The growth of fingers and bubbles in the strongly nonlinear regime of the Richtmyer-Meshkov instability*, Phys. Lett. A **251** (1999) 184-190.
- [29] A. M. Balk and E. V. Ferapontov, *Invariants of wave systems and web geometry*, in: “Nonlinear waves and weak turbulence”, ed. V. E. Zakharov, Amer. Math. Soc. Trans. Ser. 2, vol. 182, Providence, RI, 1998, pp. 1-30.
- [30] A. M. Balk and V. E. Zakharov, *Stability of weak turbulence Kolmogorov spectra* in: “Nonlinear waves and weak turbulence”, ed. V. E. Zakharov, Amer. Math. Soc. Trans. Ser. 2, vol. 182, Providence, RI, 1998, pp. 31-81.
- [31] A. M. Balk and M. B. Balk, *The enigma of the triangular pyramid*, J. Geom. **62** (1998) 13-25.
- [32] A. M. Balk, *New conservation laws for the interaction of nonlinear waves*, SIAM Review, **39** (1997) 68-94.
- [33] A. M. Balk, *A Lagrangian for water waves*, Phys. Fluids **8** (1996) 416-420.
- [34] A. M. Balk, *The suppression of short waves by a train of long waves*, J. Fluid Mech. **315** (1996) 139-150.
- [35] M. B. Balk, V. A. Petrov, and A. M. Balk, *Metric Spaces* (a textbook of Mathematical Analysis; in Russian), Smolensk, 1996.
- [36] A. M. Balk, *Kolmogorov-type spectrum for the turbulence of acoustic waves in two dimensions*, Phys. Lett. A **187** (1994) 302-308.
- [37] A. M. Balk and E. V. Ferapontov, *Wave systems with an infinite number of invariants*, Physica D **70** (1994) 100-114.

- [38] A. M. Balk and E. V. Ferapontov, *Invariants of 4-wave interactions*, Physica D **65** (1993) 274-288.
- [39] V. E. Zakharov, A. M. Balk, and E. I. Schulman, *Conservation and scattering in nonlinear wave systems*, in: "Important Developments in Soliton Theory", eds A. S. Fokas and V. E. Zakharov (Springer-Verlag, 1993), pp. 375-404.
- [40] A. M. Balk, *A new invariant for Rossby wave systems*, Phys. Lett. A **155** (1991) 20-24.
- [41] A. M. Balk, S. V. Nazarenko, and V. E. Zakharov, *New invariant for drift turbulence*, Phys. Lett. A **152** (1991) 276-280.
- [42] A. M. Balk, S. V. Nazarenko and V. E. Zakharov, *On the nonlocal turbulence of drift type waves*, Phys. Lett. A **146** (1990) 217-221.
- [43] A. M. Balk, and S. V. Nazarenko, *Physical realizability of anisotropic weak turbulence Kolmogorov spectra*, Zh. Eksp. Teor. Fiz. **97** (1990) 1827-1833; Engl. transl., Sov. Phys. JETP **70** (1990) 1031-1041.
- [44] A. M. Balk and V. E. Zakharov, *Stability of weak turbulence Kolmogorov Spectra*, in: "Integrability and Kinetic Equations for Solitons" (Naukova Dumka, Kiev 1990) pp. 417-472.
- [45] A. M. Balk, V. E. Zakharov, and S. V. Nazarenko, *Nonlocal turbulence of drift waves*, Zh. Eksp. Teor. Fiz. **98** (1990) 446-467; Engl. transl., Sov. Phys. JETP **71** (1990) 249-260.
- [46] A. M. Balk and V. E. Zakharov, *On the Stability of weak turbulence Kolmogorov spectra*, Dokl. Akad. nauk SSSR **299** (1988) 1112-1115; Engl. transl., Sov. Phys. Dokl. **33** (1988) 270-273.
- [47] A. M. Balk, *Analysis of stability of weak turbulence Kolmogorov spectra*, Ph. D. dissertation (Moscow Institute of Physics and Technology, Moscow 1988).
- [48] A. M. Balk, *Computer realization of the method of Newton's diagrams*, Zh. Vychisl. Matem. and Mat. Fiz. **24** (1984) 972-985; Engl. transl., USSR Comp. Mathematics and Math. Physics **24** (1984) 6-14.

## Other Resources

- [49] A. M. Balk, *Analytic regimes of tokamak plasma*  
arXiv:2212.06318 (2022).
- [50] A. M. Balk, *Dynamo and the Adiabatic Invariant*,  
Talk at American Mathematical Society Sectional Meeting, Special Session  
*Turbulence, Singularities, and Nonlinear Waves in Fluid Dynamics, Optics, and Plasmas*,  
10/23/2021,  
ArXiv preprint: [arxiv.org/abs/2108.11548](https://arxiv.org/abs/2108.11548) (August 2021)  
AMS abstract: [www.ams.org/amsmtgs/2283\\_abstracts/1172-85-90.pdf](https://www.ams.org/amsmtgs/2283_abstracts/1172-85-90.pdf) (October 2021)
- [51] A. M. Balk, *Spectral anti-broadening due to four-wave mixing in optical fibers*, arXiv:1502.02285 (2015).
- [52] A. M. Balk, *The extra invariant for Rossby waves and the emergence of zonal jets*, Power point presentation at the 2-nd International Workshop "Nonlinear Processes in Oceanic and Atmospheric Flows" (Madrid, Spain, 2012) <http://ifisc.uib-csic.es/nloa2012/>
- [53] A. M. Balk, *Adiabatic invariants for the dynamics of rotating three-dimensional fluid*, arXiv:1206.1018 (2012).

- [54] A. M. Balk and P. B. Weichman, *Anisotropic inverse cascade toward zonal flow in magnetically confined plasmas*, arXiv:1106.2746 (2011).
- [55] A. M. Balk, *Extra Invariant and Zonal Jets*, Talk at the Conference *Frontiers in Nonlinear Waves*, held in the Department of Mathematics, University of Arizona, Tucson, AZ, 2010, <http://www.math.arizona.edu/~nrw/NWT.2010/talks/balk.ppt>
- [56] A. M. Balk, *Zonal Jets: The Extra Invariant for Rossby Wave Dynamics*, Talk at the joint session of programs *Physics of Climate Change* and *Dynamo Theory*, Kavli Institute for Theoretical Physics, University of California Santa Barbara, 2008, video & audio recording of this talk is given at <http://doug-pc.itp.ucsb.edu/online/climate08/balk/>
- [57] A. M. Balk, *The extra invariant for the Rossby waves: The energy accumulation in the zonal flow*, Talk at Workshop *Novel Approaches To Climate*, Aspen Center For Physics, 2005, <http://homepage.mac.com/bradmarston/Presentations/BalkRossby4.pdf>
- [58] A. M. Balk and V. E. Zakharov, *Generation of structures by weak turbulence*, in: “Generation of large scale structures in continuous media”, eds S. S. Moiseev and V. V. Moshev (Perm-Moscow, 1990) pp. 38-39.
- [59] A. M. Balk, S. V. Nazarenko, and V. E. Zakharov, *On the structure of Rossby wave turbulence of zonal flow*, ib. pp. 36-37.
- [60] A. M. Balk, S. V. Nazarenko, and V. E. Zakharov, *On the structure of nonlocal drift turbulence*, ib. pp. 34-35.
- [61] A. M. Balk, S. V. Nazarenko, and V. E. Zakharov, *On the stability and locality of anisotropic weak turbulence spectra*, in: *Nonlinear and Turbulent Processes in Physics*, Vol. 2 (Naukova Dumka, Kiev, 1989), p. 342.
- [62] A. M. Balk and V. E. Zakharov, *Stability of Kolmogorov spectra of weak turbulence*, in: *Plasma Theory and Nonlinear & Turbulent Processes in Physics* (World Scientific, Singapore, 1988), pp. 359-376.
- [63] A. M. Balk, *Behavior of weak turbulence media in the vicinity of Kolmogorov spectra*, in: “The Ways of Application and Perfection of Modern Computer Means”, ed. N. N. Moiseev (Smolensk, 1987), pp. 13-18.
- [64] A. M. Balk, *Application of computers to the investigation of stability of weak turbulence Kolmogorov spectra*, ib. pp. 5-12.

**Refereed for**

Archive of Rational Mechanics and Analysis  
Astrophysical Journal  
Communications in Mathematical Sciences  
European Journal of Mechanics B/Fluids  
Fluids (MDPI)  
Journal of Fluid Mechanics  
Journal of Physical Oceanography  
Journal of Statistical Physics: Theory and Experiment  
Journal of the Mechanics and Physics of Solids  
Journal of the Meteorological Society of Japan  
Mathematics (MDPI)  
Physica D: Nonlinear Phenomena  
Physical Review A  
Physical Review E  
Physical Review Letters  
Physics Letters A  
Physics of Fluids  
Proceedings of the National Academy of Sciences of the USA  
  
National Research Council (USA)  
Science Foundation Ireland  
Israel Science Foundation

**Grant Support**

NSF Grant DMS — 0405905 *Dynamics in Random Waves*  
September 2004 - August 2008, University of Utah. PI  
NSF Grant DMS — 9971640 *Turbulent Transport by Waves*  
July 1999 — June 2003, University of Utah. PI  
NSF Grant DMS — 9423245 *Semi-Strong Turbulence*  
May 1995 — April 1997, Caltech. Co-PI  
NSF Grant DMS — 9302013 *Pattern Formation, Turbulence, and Singularities in PDEs*  
June 1994 — May 1997, University of Arizona. Co-PI

## Courses taught

### University of Utah, 1997 - present

- Graduate courses: *Partial differential equations,*  
*Applied complex variables and asymptotic methods,*  
*Introduction to fluid dynamics,*  
*Nonlinear waves,*  
*Applied Fourier analysis,*  
*Asymptotic and perturbation methods,*  
*Nonlinear dynamical systems,*  
*Introduction to applied mathematics,*  
*Applied linear operators and spectral methods,*  
*Introduction to Partial differential equations,*  
*Ordinary differential equations.*
- Undergraduate courses: *Differential equations and linear algebra*  
*Vector calculus and partial differential equations,*  
*Applied Complex Variables for engineers,*  
*Partial differential equations for engineers,*  
*Elementary mathematical fluid dynamics,*  
*Foundations of Analysis I*  
*Ordinary differential equations,*  
*Linear algebra,*  
*Engineering Calculus I, II,*  
*Calculus II, III.*

### California Institute of Technology, 1993-1996

- Graduate courses: *Perturbation methods,*  
*Wave turbulence.*

### University of Arizona, 1992-1993

- Undergraduate course: *Mathematical analysis for engineers.*