# Hannes Uecker, Research

My research centers around the analysis of nonlinear PDE, mathematical modeling, and numerical simulation and bifurcation analysis. For an overview, my research can be arranged into six overlapping areas, with the more recent interests first.

1. Bifurkation and pattern formation in PDE systems over bounded domains, including numerical bifurcation analysis (pde2path), Classical and extended models from physics, chemistry and biology. [9, 12, 13,14,15, 16, 18, 20,22, 25,30,42,44, 43, 52,62, 65, 63, 71]

2. Development of pde2path. [76,19, 30, 31], see also the various pde2path tutorials

3. Pattern formation in infinite time–horizon optimal control with PDE constraints. [11, 17,22, 25]

4. Nonlinear Optics and related systems (NLS and other dispersive equation related problems). [23,24, 26, 27,28, 40,47, 51, 57,58,68,73, 61]

5. Fluid flow, in particular film flow with a free boundary over inclined planes. [45, 49, 59, 48, 55,53, 66, 69]

6. Pattern formation over unbounded domains (dissipative problems related to the Ginzburg–Landau equations and other modulation equation). [29, 79,33, 54,67,64, 74, 72,75]

Publications, last update 5. November 2024. Note: the linked preprints may differ slightly from the published versions.

Books
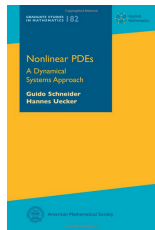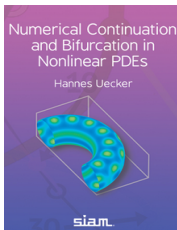
Numerical continuation and bifurcation in Nonlinear PDEs, SIAM, 2021, SIAM
Nonlinear PDEs: A Dynamical Systems Approach, AMS, Graduate Studies in Mathematics 182, 2017, mit Guido Schneider. AMS

Preprints

1. Traveling vegetation-herbivore waves can sustain ecosystems threatened by droughts and population growth, 2024, (mit J. Singha and E. Meron), preprint

2. Localized steady and oscillatory states near a Turing-Hopf instability in a semiconductor model, 2024, (mit F. Al Saadi, E. Knobloch and A. Meiners), preprint

3. Phase transition and minimal interfaces on manifolds with conical singularities, 2024, (mit D. Grieser, S. Held and B. Vertman), preprint

Peer reviewed journal publications and book chapters

2021–...

4. Numerical continuation and bifurcation for differential geometric PDEs, *NMTMA*, OA-2024-0005, 2024, (mit A. Meiners), preprint

5. Time-dependent localized patterns in a predator–prey model, *Chaos*, 34, 043143, 2024, (mit F. Al Saadi, E. Knobloch and M. Nelson), preprint

6. Nonlinear dynamics of modulated waves on graphene like quantum graphs, Mathematische Nachrichten 295 (11), 2147-2170, 2022, (mit S. Gilg and G. Schneider), preprint

7. Origin of Jumping Oscillons in an Excitable Reaction-Diffusion System, PRE, E 104 (6), L062201 2021, (mit E. Knobloch and A. Yochelis), preprint

8. Numerical continuation and bifurcation in Nonlinear PDEs - Algorithms, Applications, and Experiments, Jahresbericht der DMV, 2021.

9. Localized and extended patterns in the cubic-quintic Swift-Hohenberg equation on a disk, *Phys. Rev. E*, 104:014208, 2021, (mit N. Verschueren und E.Knobloch) preprint

10. Optimal spatial patterns in feeding, fishing, and pollution, *DCDS-S*, 2021, preprint

11. Optimal Stock–Enhancement of a Spatially Distributed Renewable Resource, *Journal of Economic Dynamics & Control*, 123, 104060, 2021 (mit Th. Upmann, L. Hammann, B. Blasius)

2016–2020

12. Bending and pinching of three-phase stripes: From secondary instabilities to morphological deformations in organic photovoltaics, *Phys. Rev. E*, 102, 062213, 2020 (mit A. Shapira, N. Gavish und A. Yochelis)

13. Stripes on finite domains: Why the zigzag instability is only a partial story, *Chaos*, 30, 073104, 2020 (mit A. Shapira und A. Yochelis) preprint

14. The role of spatial self-organization in the design of agroforestry system, *PLOS ONE*, 15:7, e0236325, 2020 (mit O. Tzuk und E. Meron) preprint

15. Snaking branches of planar BCC fronts in the 3D Brusselator, *Physica D*, 406, 132383, 2020, (mit D. Wetzel) preprint

16. Defect–like structures and localized patterns in the cubic–quintic–septic Swift–Hohenberg equation, *PRE*, 100:1, 012204, 2019, mit E. Knobloch und D. Wetzel) preprint

17. Optimal fishery with Coastal Catch, *Natural Resource Modelling*, e12235, 2019 (mit D. Grass und Th. Upmann) preprint

18. Continuation for thin film hydrodynamics and related scalar problems, in *Comput. Methods Appl. Sci.*, 50, Springer, Cham, 2019 (mit S. Engelnkemper, S. V. Gurevich, D. Wetzel and U. Thiele), preprint.

19. Hopf bifurcation and time periodic orbits with pde2path - algorithms and applications, *Comm. in Comp. Phys.*, 2019, preprint, pde2path homepage.
(This replaces the old version (2016), where the algorithms, applications, and implementations were reviewed in a single document. Now the paper focusses on the algorithms and applications, while the implementation is reviewed in a Tutorial on Hopf bifurcation; see also pde2path tutorials.

20. Mean field approach to first and second order phase transitions in ionic liquids, *PRE*, 95:060201, 2017, preprint, (mit S. Bier, N. Gavish and A. Yochelis)

21. Desertification by Front Propagation?, Journal of Theoretical Biology 418 (2017), 27–35, (mit Y. Zelnik, U. Feudel und E. Meron) preprint

22. Optimal management and spatial patterns in a distributed shallow lake model, 1:1-21, 2017, (mit D. Grass), preprint

23. Low regularity justification results for envelope approximations of nonlinear wave packets in periodic media, Asymptotic Analysis, 99 (1-2), pp. 53-65, 2016 (mit K. Matthies), preprint

24. Sine-Gordon solitons in networks: Scattering and transmission at vertices, Europ. Phys. Letters 115: 50002, 2016 (mit Z. Sobirov, D. Babajanov, K. Nakamura and D. Matrasulov), preprint

25. Optimal control and spatial patterns in a semi arid vegetation system, *Natural Resource Modeling*, 29:2, 229–258, 2016, preprint

26. Bifurcation of Nonlinear Bloch Waves from the Spectrum in the Gross-Pitaevskii Equation, *Journal of Nonlinear Science*, 26:3, 581–618, 2016, (mit T. Dohnal), preprint

2011–2015

27. Exact solutions of the Cauchy problem for the linearized KdV equation on metric star graphs, Uzbek Mathematical J, 2015:3, 143-154, (mit Z. Sobirov und M. Akhmedov), preprint

28. Soliton transport in tubular networks: transmission at vertices in the shrinking limit, PRE 91, 023209, 2015, (mit D. Grieser, Z. Sobirov, D. Babajanov and D. Matrasulov), preprint

29. Individual-based model for quorum sensing with background flow, *Bull. Math. Biology*, (mit J. Müller und B. Hense), 2014, preprint

30. Numerical results for snaking of patterns over patterns in some 2D Selkov–Schnakenberg Reaction–Diffusion systems, *SIADS*, 13-1:94–128, 2014 (mit D. Wetzel) preprint,

31. pde2path – a Matlab package for continuation and bifurcation in 2D elliptic systems, *NMTMA* (Numerical Mathematics: Theory, Methods and Applications), 7:58–106, 2014 (mit D. Wetzel und J. Rademacher) preprint, pde2path homepage

32. Approximating the dynamics of communicating cells in a diffusive medium by ODEs -Â Homogenization with Localization, *J. Math. Biology*, 2012, (mit J. Müller) preprint

33. Diffusive stability and diffusive mixing of periodic wave trains in reaction diffusion systems. *JDE*, 252, 3541–3574, 2012. (mit B. Sandstede, A. Scheel and G. Schneider) preprint

34. Self-similar decay to the marginally stable ground state in a model for film flow over inclined wavy bottoms, *EJDE*, 2012:61, 1–51, 2012, (mit T. Häcker und G. Schneider) preprint

35. Traveling interface modulations in the NH_3+O_2 reaction on a Rh(110) surface, *Physical Chemistry Chemical Physics*, 14, 5260–5264, 2012, (mit M. Rafti, F. Lovis, V. Krupennikova and R. Imbihl) preprint

36. Corrigendum to 43, *Proc. Royal Soc. Edinburgh*, 141A, 819-824, 2011 (mit R. Kaiser), preprint

37. Interfacing Fortran routines from Matlab in a simple and efficient way - with applications to ordinary and partial differential equations *Summer School Modern Computational Science, Oldenburg 2011*, Universitätsverlag Oldenburg, 2011, preprint,

38. Local existence and uniqueness of solutions of the weak electrolyte model describing electroconvection in nematic liquid crystals. *ZAMM*, 91:3, 247-256, 2011 (mit W.-P. Düll und G. Schneider) preprint

39. Erratum to (published version of) 47, *Physica D*, 240, 357-362, 2011 (mit T. Dohnal)preprint

40. Interaction of modulated pulses in nonlinear oscillator chains, *J. Diff. Eq. Appl.*, 17:3, 279-298, 2011 (mit G. Schneider und M. Wand) preprint

2006-2010

41. Amplitude equations – an invitation to multiple scale analysis *Summer School Modern Computational Science, Oldenburg 2010*, Universitätsverlag Oldenburg, 2010, preprint,

42. Statistics for surface modes of nanoparticles with shape fluctuations, *Commun. in Comp. Physics, 8, 1224*, 2010, (mit F. Rüting), preprint,

43. Well-posedness of some initial-boundary-value problems for dynamo-generated poloidal magnetic fields, *Proc. Royal Soc. Edinburgh*, 139A, 1209-1235, 2009 (mit R. Kaiser) preprint

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45. An integral boundary layer equation for film flow over inclined wavy bottoms, *Phys. of Fluids*, 21, 092105, 2009. (mit T. Häcker) preprint

46. A short ad hoc introduction to spectral methods for parabolic PDE and the Navier–Stokes equations, in *Summer School Modern Computational Science, Oldenburg 2009*, Universitätsverlag Oldenburg, 2009 preprint, software

47. Coupled Mode Equations and Gap Solitons for the 2D Gross-Pitaevsky equation with a non-separable periodic potential, *Physica D*, 238: 860-879, 2009. (mit T. Dohnal) (updated version)

48. Linear Resonance in viscous films on inclined planes. *IJ Mutiphase Flow* 34: 580–589, 2008. (mit A. Wierschem, V. Bontozoglou, C. Heining, und N. Aksel)

49. A Hopf-bifurcation theorem for the vorticity formulation of the Navier-Stokes equations in $\mathbb{R}^3$, *Comm. PDE* 33:5, 772–783, 2008. (mit A. Melcher and G. Schneider) preprint

50. A remark about the justification of the nonlinear Schrödinger equation in quadratic spatially periodic media, *ZAMP*, 59:1-4, 2008 (mit C. Blank, M. Chirilus-Bruckner, C. Chong, V. Lescarret and G. Schneider) preprint

51. Separation of internal and interaction dynamics for NLS-described wave packets with different carrier waves, *Math. Anal. Appl. 347*, 304Â314 (2008), (mit M. Chirilus-Bruckner, C. Chong, and G. Schneider) preprint

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54. Exponential averaging and traveling waves in rapidly varying periodic media, *Mathematische Nachrichten*, 280:4, 408-422, 2007 (mit K. Matthies and G. Schneider) preprint

55. Self–similar decay of localized perturbations of the Nusselt solution for the Navier–Stokes equations on an inclined plane, *Arch. Rat. Mech. Anal.* 184:3, 401–447, 2007 preprint

56. The amplitude equations for the first instability of electro-convection in nematic liquid crystals in case of two unbounded space directions, *Nonlinearity* 20:1361-1386, 2007. (mit G. Schneider) preprint

57. On the interaction of modulating pulses with different carrier waves, *Mathematical Methods Applied Sciences*, 30:15, 1965–1978, 2007. (mit M. Chirilus-Bruckner und G. Schneider) preprint

58. The mathematics of light pulses in dispersive media, *Jahresberichte der DMV*, 109:3, 139-161, 2007 (mit G. Schneider) preprint

59. A spatially periodic Kuramoto-Sivashinsky equation as a model problem for inclined film flow over wavy bottom. *EJDE* 118, 1-18, 2007, (mit A. Wierschem) preprint

60. Simulation of the life cycle of adsorbate islands on the Pt(100) surface during the NO+NH$_3$ reaction. *Chem. Phys. Letters*, 421:4–6, 577–583. 2006. (mit M. Rafti, J. L. Vicente and R. Imbihl) preprint

61. Justification of the Nonlinear Schrödinger equation in spatially periodic media, *ZAMP*, 57:6, 905–939, 2006 (mit K. Busch, G. Schneider and L. Tkeshelashvili) preprint

2001-2005

62. Pattern formation for NO+NH$_3$ on Pt(100) – 2-dimensional numerical results, *Phys. Rev.E*, 71, 016207, 2005. preprint

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64. Stable transport of information near essentially unstable localized structures. *Discrete Contin. Dyn. Syst.B* 4:2, 349–390, 2004. (mit Th. Gallay und G. Schneider) preprint

65. Relaxed plasma vacuum states in cylinders. *Q.J. Mech. Appl. Math.*, 57:1, 1–17, 2004. (mit R. Kaiser) preprint

66. Self–similar decay of localized perturbations in the Integral Boundary Layer equation. *Journal Diff. Eq.*, 207:2, 407–422, 2004.preprint

67. Validity of the Ginzburg-Landau approximation in pattern forming systems with time periodic forcing. *Dynamics and Bifurcations of Patterns in Dissipative Systems*, World Scientific, 39–57, 2004. (mit N. Breindl und G. Schneider) preprint

68. Existence and stability of modulating pulse solutions in Maxwell's equations describing nonlinear optics. *ZAMP* 54, 677-712, 2003. (mit G. Schneider) preprint

69. Approximation of the Integral Boundary Layer equation by the Kuramoto–Sivashinsky equation. *SIAM J. Appl. Math.* 63:4, 1359–1377, 2003. preprint

70. Almost global existence and transient self similar decay for Poiseuille flow at criticality over exponentially long times. *Physica D* 185:3–4, 209–226, 2003. (mit G. Schneider) preprint

71. Adiabatic reduction and hysteresis of the LFI–model of NO+NH$_3$ on Pt(100). *Chem. Phys. Let.*, 382, 232–244, 2003. (mit R. Imbihl, M. Rafti, I.M. Iruzun, J.L. Vicente und E.E. Mola) preprint

72. Stability and diffusive dynamics on unbounded domains. In *Ergodic Theory, Analysis and Efficient Simulation of Dynamical Systems*, ed. B. Fiedler, Springer, 563-584, 2001. (mit A. Mielke und G. Schneider)preprint

73. Nonlinear coupled mode dynamics in hyperbolic and parabolic periodically structured spatially extended systems. *Asymptot. Anal.* 28:2, 163-180, 2001. (mit G. Schneider) preprint

74. Stable modulating multi-pulse solutions for dissipative systems with resonant spatially periodic forcing. *J. Nonlin. Sci.*,11:2, 89-121, 2001. preprint

75. Diffusive stability of rolls in the two-dimensional real and complex Swift–Hohenberg equation. *Comm. PDE* 24:11&12, 2109-2146, 1999.preprint

Proceedings

76. pde2path – V2 : multi-parameter continuation and periodic domains, 2014, in H. Ecker, A. Steindl, S. Jakubek, eds, ENOC 2014 - Proceedings of 8th European Nonlinear Dynamics Conference, ISBN: 978-3-200-03433-4. (mit T. Dohnal, J. Rademacher und D. Wetzel), preprint, pde2path homepage

77. Modeling of film flows over inclined wavy bottoms, *PAMM* 8:10721-10722, 2009 (mit T. Häcker)

78. Resonance in viscous film flow over topography *PAMM* 7:4100025–4100026, 2008 (mit C. Heining, A. Wierschem, V. Bontozoglou und N. Aksel)

79. Mathematical theory for the Ginzburg-Landau approximation in pattern forming systems with time-periodic forcing – with applications to electro-convection in nematic liquid crystals. *Proceedings of Equa∂iff–11*: 507–517, 2005. (mit N. Breindl und G. Schneider) preprint

80. Local in time nonlinear stability of pulses in an unstable medium. *XIV^{t}h International Congress on Mathematical Physics, Lisboa 2003*, 296–303, World Scientific, 2005. (mit R.L. Pego und G. Schneider)

81. Rolls and modulating pulses in Swift–Hohenberg type of equations, in *International Conference on Differential Equations, Equadiff 99*, World Scientific, 408-413, 2000.

Thesis

- Stabilitätsuntersuchungen in einem Modell für Formgedächtnislegierungen, Diplomarbeit, Universität Hannover, 1996. Veröffentlicht als Preprint A3 der Reihe *Spannungs– und Verzerrungsbedingte Phasenübergänge in Ingenieurswerkstoffen*, Forschungsprojekt der VW–Stiftung: I 70 284. pdf

- Rollen und modulierende Multipulse in musterbildenden Systemen, Dissertation, Universität Bayreuth, 2000. (siehe 75,74)

- Qualitative Theorie nichtlinearer partieller Differentialgleichungen der Mathematischen Physik, Habilitationsschrift, Universität Karlsruhe, 2004. (kumulativ, siehe 73–61, 54)

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