

CURRICULUM VITAE

Dr.-Ing. Werner Würz

1. Personal Data

| | |
|-------------------------|---|
| Date and place of birth | April 5, 1959, Fulda, Germany |
| Citizenship | German |
| Permanent address | Hohewartweg 7, 70839 Gerlingen |
| Business address | Institute of Aerodynamics and Gas Dynamics, Pfaffenwaldring 21, 70550 Stuttgart |
| Phone | +49 (0711) 685 3470 (office) +49 (07156) 929454 (home) |
| Fax | +49 (0711) 685 3470 (office) |
| E-mail | wuerz@iag.uni-stuttgart.de |
| Internet home page | http://www.iag.uni-stuttgart.de/laminarwindkanal |

2. Education, Academic Degrees and Titles

| | |
|---|-----------|
| Undergraduate study, University of Stuttgart, 'Aerospace Engineering' | 1978-1986 |
| Dipl.-Ing., University of Stuttgart, Thesis title: ' <i>Design, construction and test of an experimental set-up for towing tests with wind turbine models</i> ' | 1986 |
| Dr.-Ing., University of Stuttgart, Institute of Aerodynamics and Gas Dynamics (IAG), Dissertation title: ' <i>Hot wire measurements with respect to laminar-turbulent transition in attached and separated boundary layers and comparison to Linear Stability Theory and empirical transition criteria</i> ' | 1995 |

3. Employment History

| | |
|--|--------------|
| Junior Research Scientist at IAG, Laminar Wind Tunnel, Stuttgart | 1986-1995 |
| Leading Research Scientist at IAG, Head of the section 'Laminar Wind Tunnel' | 1995-present |

4. Languages

| | |
|---------|--------|
| German | fluent |
| English | good |

5. Professional Activities

Current Fields of Interest

Key words: wind tunnel testing, viscous fluid mechanics, boundary layer flows, subsonic speeds, laminar flow receptivity, laminar flow instability, laminar-turbulent transition, airfoil design, aero-acoustics

Experimental studies of various stages of boundary layer transition. Receptivity characteristics of 2D boundary layers (with and without pressure gradients) to 3D external perturbations (roughness, vibrations, acoustics, turbulence, etc.). Stability characteristics of 2D boundary layers with respect to traveling 2D and 3D instability modes. Weakly nonlinear interactions of instability modes in laminar boundary layers.

Boundary layer induced noise on airfoils, development of aero-acoustic measurement procedures for non anechoic wind tunnels. Investigation of turbulence properties relevant for acoustic radiation.

Airfoil design for various applications, standard wind tunnel testing for third party companies

6. Teaching Experience

- Lecture on "Flow Visualization" at Stuttgart University, 2000 - present
- Lecture on "Wind Tunnel Measurement Technique" at Stuttgart University, 2006 - present
- Research advisor of several graduate and 2 postgraduate students at Stuttgart University

7. List of 5 most important publications

- Würz W., Herr S., Wörner A., Rist U., Wagner S., Kachanov Y.S.: *Three-Dimensional Acoustic-Roughness Receptivity of a Boundary Layer on an Airfoil. Experiment and DNS*, Journal of Fluid Mechanics, vol.468, pp1-29, 2003
- Würz W., Guidati S., Herrig A., Luth Th., Wagner S.: *Measurement of trailing edge noise by a coherent particle velocity method*, ICMAR 2004, Novosibirsk, 28.6.-2.7.2004
- Ivanov A.V., Würz W., Herr S., Wagner S., Kachanov Y.S.: *Experimental investigation of 3D acoustic receptivity of an airfoil boundary layer due to surface vibrations*, European Journal of Mechanics -B/Fluids, 24, pp621-641, 2005
- Sartorius D., Würz W., Ries T., Kloker M., Wagner S., Borodulin V.I., Kachanov Y.S.: *Experimental Study of Resonant Interactions of Instability Waves in an Airfoil Boundary Layer*, Govindarajan, Rama. (Ed.), Laminar-Turbulent Transition, Proceedings of the Sixth IUTAM Symposium on Laminar-Turbulent Transition, Bangalore, India, 2004, , Springer Verlag Berlin, 2006, ISBN 1402034598
- Herrig A., Würz W., Krämer E., Wagner S.: *Trailing-Edge Noise Measurements on NACA 0012 Airfoils Using the Coherent Particle Velocity Method*, 15th International Congress of Sound and Vibration, Daejeon, Korea, 06.-10.July 2008

8. Reviewed Articles in Journals and Books

- Lutz Th., Würz W., Wagner S.: *Numerical Optimization and Wind-Tunnel Testing of Low Reynolds-Number Airfoils*; Conference on Fixed, Flapping and Rotary Wing Vehicles at very Low Reynolds Numbers, Notre Dame, Indiana, 5.-7.6.2000, published in: Thomas J. Mueller (ed.): *Fixed and Flapping Wing Aerodynamics for Micro Air Vehicle Applications*, Vol. 195, AIAA 2001
- Herr S., Wörner A., Würz W., Rist U., Wagner S.: *Experimental/Numerical Investigation of the Influence of a Pressure Gradient on Acoustic Roughness Receptivity in the Boundary Layer of a 2D Airfoil*; 12. AGSTAB Fachsymposium Stuttgart 2000, Wagner S., Rist U., Heinemann H.J., Hilbig H. (Eds.), *New Results in Numerical and Experimental Fluid Mechanics III*, NNFM, Vol.77, Springer-Verlag Berlin, 2002
- Herr S., Würz W., Wagner S.: *Experimentelle Untersuchungen zur wirbelbehafteten Rezeptivität einer Oberflächenstörung an einem 2-dimensionalen Tragflügelprofil*; 13.DGLR/AG-STAB Fach-Symposium München, 12.-14.11.2002, *New Results in Numerical and Experimental Fluid Mechanics III*, NNFM, Springer-Verlag Berlin
- Würz W., Herr S., Wörner A., Rist U., Wagner S., Kachanov Y.S.: *Three-Dimensional Acoustic-Roughness Receptivity of a Boundary Layer on an Airfoil. Experiment and DNS*, Journal of Fluid Mechanics, vol.468, pp1-29, 2003
- Herr S., Würz W., Wörner A., Rist U., Wagner S., Ivanov A., Kachanov Y.S.: *Systematic investigations of 3D acoustic receptivity with respect to steady and unsteady disturbances. Experiment and DNS*, Wagner S., Kloker M., Rist U.(Eds.), *Recent Results in Laminar-Turbulent Transition - Selected Numerical and Experimental Contributions from the DFG-Verbundschwerpunktprogramm "Transition" in Germany*, NNFM, Vol.86, pp.75-90, Springer-Verlag Heidelberg, 2003
- Ivanov A.V., Würz W., Herr S., Wagner S., Kachanov Y.S.: *Experimental investigation of 3D acoustic receptivity of an airfoil boundary layer due to surface vibrations*, European Journal of Mechanics -B/Fluids, 24, pp621-641, 2005
- de Paula I.B., Würz W., Medeiros M.A.F.: *Experimental Study of a Tollmien-Schlichting wave interacting with a shallow 3-D roughness element*, Journal of Turbulence Volume 9 N 7 (2008) pp.1-23
- Schreyer A.M., Würz W., Krämer E., Talamelli A., Alfredsson H.: *Experimental Flow Studies on Separation and Reattachment in the Vicinity of Sharp, Wedge Shaped Leading Edges at Low Reynolds Numbers*, A. Dillmann et al. (Eds.): *Numerical & Experimental Fluid Mechanics VII*, NNFM 112, pp. 273- 280, Springer-Verlag Berlin Heidelberg 2010
- Cerretelli C., Gharaibah E., Toplack G., Gupta A., Würz W.: *Unsteady Separation Control for Wind Turbine Applications at Full Scale Reynolds Number*, AIAA JOURNAL Vol. 48, No. 7, July 2010
- Herrig A., Kamruzzaman M., Würz W., Wagner S.: *Broadband Airfoil Trailing-Edge Noise Prediction from Measured Surface Pressures and Spanwise Length Scales*, Int. Journ. of Aeroacoustics, accepted 2010
- Kamruzzaman M., Herrig A., Lutz T., Würz W., Krämer E., Wagner S.: *Comprehensive Evaluation and Assessment of Trailing Edge Noise Prediction Based on Dedicated Measurements*, Noise Control Engineering Journal (NCEJ), accepted 2010

9. Publications in Journals & Conference Proceedings

Complete list of scientific publications consists of more than 50 papers, reports, and abstracts. Included here is a *selected* list from the past 10 years:

- Würz W., Herr S., Wörner A., Rist U., Wagner S., Kachanov Y.S.: *Study of 3D Wall Roughness Acoustic Receptivity on an Airfoil*, Fasel H., Saric W. (Eds.), *Laminar-Turbulent Transition*, proc. of the IUTAM Symposium Sedona, Az./USA, September 13-17, 1999, pp. 91-96, Springer Verlag Berlin, 2000
- Würz W., Herr S., Wörner A., Rist U., Wagner S., Kachanov Y.S.: *Experimental and Numerical Investigation of 3D Acoustic Receptivity due to Localized Wall Roughness*; Proceedings of the ICMAR 2000, Novosibirsk, 9.-15.7.2000
- Herr S., Würz W., Wörner A., Rist U., Wagner S., Kachanov Y.S.: *Experimental and Numerical Investigation of 3D Wall Roughness Acoustic Receptivity on an Airfoil*; ICTAM 2000, Chicago, 27.8.-2.9.2000
- Wörner A., Rist U., Herr S., Würz W., Wagner S., Kachanov Y.S.: *Study of the Acoustic Receptivity of a Blasius Boundary Layer in the Presence of a Surface Non-Uniformity*; ECCOMAS 2000, Barcelona, 11.-14.9.2000
- Lang M., Marxen O., Rist U., Wagner S., Würz W.: *LDA-Messungen zur Transition in einer laminaren Ablöseblase; Lasermethoden in der Strömungsmesstechnik*, 8. Fachtagung der Gala, Freising-Weihestephan, 12.-14.9.2000
- Ivanov A.V., Würz W., Herr S., Wagner S.: *Experimental Investigation of 3-D Acoustic Receptivity due to a Surface Vibration on an Airfoil*; EUROMECH Colloquium 423 'Boundary-Layer Transition in Aerodynamics', Stuttgart, 2.-4.4.2001
- Herr S., Würz W., Wagner S.: *Experimentelle Untersuchungen zur Charakterisierung des dominanten Störspektrums in der Anströmung anhand der Rezeptivität einer Oberflächenstörung an einem 2-dimensionalen Tragflügelprofil*, 10. AG STAB-Workshop, Göttingen, 14.-15.November 2001
- Würz W., Herr S., Wagner S., Kachanov Y.S.: *A First Experimental Approach to the Distributed 3D-Vortex Receptivity of a Boundary Layer on an Airfoil*, Proceedings of the ICMAR 2002, Novosibirsk, 1.-7.7.2002
- Ivanov A.V., Würz W., Herr S., Wagner S., Kachanov Y.S.: *Experimental Study of Essentially Non-Stationary Acoustic Receptivity of a Boundary Layer on an Airfoil due to Surface Non-Uniformities*; Proceedings of the ICMAR 2002, Novosibirsk, 1.-7.7.2002
- Sartorius D., Würz W., Wagner S.: *Auslegung eines Membranaktuators unter Berücksichtigung der Stabilitäts- und Rezeptivitätseigenschaften der Grenzschicht* 11. AG STAB-Workshop, Göttingen, 4.-5.November 2003
- Guidati S., Herrig A., Ostertag J., Würz W., Wagner S.: *Numerical Simulation and Measurement of Boundary-Layer Induced Noise on Wing Sections*, 4th Aeroacoustics Workshop, Aachen, 26.-27. February 2004
- Würz W., Sartorius D., Wagner S., Borodulin V.I., Kachanov Y.S.: *Experimental study of weakly nonlinear interactions of instability waves in a non self-similar boundary layer on an airfoil, Part I: Base flow and initially tuned resonances*, ICMAR 2004, Novosibirsk, 28.6.-2.7.2004
- Sartorius D., Würz W., Wagner S., Borodulin V.I., Kachanov Y.S.: *Experimental study of weakly nonlinear interactions of instability waves in a non self-similar boundary layer on an airfoil, Part II: Influence of frequency and spanwise-wavenumber detunings*, ICMAR 2004, Novosibirsk, 28.6.-2.7.2004
- Würz W., Guidati S., Herrig A., Luth Th., Wagner S.: *Measurement of trailing edge noise by a coherent particle velocity method*, ICMAR 2004, Novosibirsk, 28.6.-2.7.2004
- Sartorius D., Würz W., Wagner S., Borodulin V.I., Kachanov Y.S.: *Resonant Interactions of 3D Instability Waves in an Airfoil Boundary Layer for Harmonic and Broadband Perturbations*, XXI. International Congress of Theoretical and Applied Mechanics (ICTAM), Warsaw, 15.-21.8.2004
- Sartorius D., Würz W., Ries T., Kloker M., Wagner S., Borodulin V.I., Kachanov Y.S.: *Experimental Study of Resonant Interactions of Instability Waves in an Airfoil Boundary Layer*, Govindarajan, Rama. (Ed.), *Laminar-Turbulent Transition*, Proceedings of the Sixth IUTAM Symposium on Laminar-Turbulent Transition, Bangalore, India, 2004, , Springer Verlag Berlin, 2006, ISBN 1402034598
- Lutz Th., Würz W., Herrig A., Braun K., Wagner S.: *Numerical Optimization of Silent Airfoil Sections*, Deutsche Windenergie-Konferenz 2004, Wilhelmshaven, 20.-21.10.04
- Herrig, W. Würz, Th. Lutz, K. Braun, E. Krämer and S. Oerlemans: *Trailing-Edge Noise Measurements of Wind Turbine Airfoils in Open and Closed Test Section Wind Tunnels*, Windturbinennoise2005, Berlin
- Würz W., Sartorius D., Kloker M., Ries T., Wagner S., Smorodsky B., Borodulin V.I., Kachanov Y.S.: *Experimental, numerical and theoretical investigation of weakly nonlinear stages of transition in a non self-similar boundary layer*, 12. AG STAB-Workshop, Göttingen, 8.-9.November 2005
- Herrig A., Würz W., Krämer E.: *Akustisches Messverfahren für den Einsatz in Windkanälen mit hohem Hintergrundstörpegel*, 12. AG STAB-Workshop, Göttingen, 8.-9.November 2005

- de Paula I.B., de Medeiros M.A.F., Würz W., Mendonça M.T.: *Fundamental resonance induced by a 3D shallow roughness*, 58th Annual Meeting of the Division of Fluid Mechanics, American Physical Society, Chicago, 20.-22. November 2005
- Herrig A., Würz W., Lutz Th., Krämer E.: *Trailing-Edge Noise Measurements using a Hot-Wire Based Coherent Particle Velocity Method*, 24th AIAA Applied Aerodynamics Conference, San Francisco, 5.-8. June 2006
- Lutz Th., Herrig A., Würz W., Kamruzzaman M., Krämer E.: *Design and Wind-Tunnel Verification of Low-Noise Airfoils for Wind Turbines*, 24th AIAA Applied Aerodynamics Conference, San Francisco, 5.-8. June 2006
- de Paula I. B., de Medeiros M. A. F., Würz W., Mendonça M. T.: *Experimental study on the boundary layer transition induced by a shallow 3D roughness element*, 6th Euromech Fluid Mechanics Conference, Stockholm, 26-30 June 2006
- Lutz Th., Würz W., Herrig A., Braun K., Krämer E., Schepers J.G., Curvers A.P.W.M., Oerlemans S., Matesanz A., Ahrelt R., Maeder T.: *New Results from the European SIROCCO Project: Silent Rotors by Acoustic Optimization*, DEWEK 2006, 8th German Wind Energy Conference, Bremen, 22.-23. November 2006
- Kobiela B., Lerch A., Herrig A., Würz W.: *Grenz-N-Faktor Bestimmung bei Reynoldszahlen < 600.000 - Ein neuer Ansatz für kombinierte Freiflug- und Windkanalmessungen*, Segelflug-Symposium, Darmstadt, 23.-24. November 2006
- Herrig A., Würz W., Lutz Th., Krämer E., Wagner S.: *Trailing-Edge Noise Measurements of a NACA 0012 Airfoil using the Coherent Particle Velocity Method*, Int. Conference on Methods of Aerophysical Research ICMAR, 05.-10. Feb. 2007
- Herrig A., Würz W., Lutz Th., Krämer E., Wagner S.: *Measurement of Airfoil Trailing Edge Noise with the Coherent Particle Velocity Method*, 33rd German Annual Conference on Acoustic (DAGA), Stuttgart, 19.-22. März 2007
- Schepers J.G., Curvers T., Oerlemans S., Braun K., Lutz Th., Herrig A., Würz W., Matesanz A., Fisher M., Kogler K., Maeder T.: *Sirocco: Silent Rotors by Acoustic Optimisation*, Second International Meeting on Wind Turbine Noise, Lyon, 20.-21. September 2007
- Müller A., Müller M., Neumann S.O., Würz W.: *Numerische Untersuchung der aerodynamischen Kräfte an einem Flügelement mit unterbrochenem Hinterkantenschlitz*, ANSYS Conference & 25th CADFEM Users' Meeting 2007, Dresden, 21.-23. November 2007
- Herrig A., Würz W., Krämer E., Wagner S.: *Hitzdraht-basierte Messungen von Hinterkantenlärm an NACA-0012-Profilen*, AG STAB Workshop, Göttingen, 14.-15. Nov. 2007
- Herrig A., Würz W., Krämer E., Wagner S.: *New CPV-Results of NACA 0012 Trailing-Edge Noise*, Int. Conference on Methods of Aerophysical Research ICMAR, 30. June-06. July 2008
- de Paula I.B., Sartorius D., Krämer E., Kachanov Y.S.: *Experimental Study of Broadband Resonant Interactions in an Non-Self Similar Boundary Layer of an Airfoil*, Int. Conference on Methods of Aerophysical Research ICMAR, 30. June-06. July 2008
- Herrig A., Würz W., Krämer E., Wagner S.: *Trailing-Edge Noise Measurements on NACA 0012 Airfoils Using the Coherent Particle Velocity Method*, 15th International Congress of Sound and Vibration, Daejeon, Korea, 06.-10. July 2008
- Würz W., Sartorius D., Kloker M., Wagner S., Smorodsky B., Borodulin V.I., Kachanov Y.S.: *Weakly nonlinear stages of transition in an airfoil boundary layer. A combined experimental, numerical and theoretical investigation*, Deutscher Luft- und Raumfahrtkongress der DGLR, Darmstadt, 23.-25. September 2008
- Herrig A., Würz W.: *Untersuchungen zur atmosphärischen Turbulenz in Bodennähe*, 32. Symposium für Segelflugzeugentwicklung, Gersfeld, 20.-21. 11. 2008
- Käser, K., Ruppert R., Würz W.: *Untersuchungen zur Aerodynamik bespannter Tragflügel am Beispiel des Archaeopteryx*, 32. Symposium für Segelflugzeugentwicklung, Gersfeld, 20.-21. 11. 2008
- Cerretelli C., Gharaibah E., Toplack G., Gupta A., Würz W.: *Unsteady Separation Control for Wind Turbine Applications at Full Scale Reynolds Number*, 47th AIAA Aerospace Sciences Meeting, AIAA 2009-380, Orlando, 5.-8. January 2009
- Kamruzzaman M., Lutz Th., Ivanov A., Herrig A., Würz W. and Krämer E.: *Evaluation of Measured Anisotropic Turbulence Two-point Correlation Data for the Accurate Prediction of the Turbulence Noise Sources*, 15th AIAA/CEAS Aeroacoustics Conference, Miami, USA, 11-13 May, 2009
- M. Kamruzzaman M., Herrig A., Lutz Th., Würz W., Kraemer E. and Wagner S.: *Comprehensive Evaluation and Assessment of Trailing Edge Noise Prediction Based on Dedicated Measurements*, 3rd Conference on Wind Turbine Noise, 17-19 June, Aalborg, Denmark, 2009

- de Paula I. B., Würz W., Krämer E., Borodulin V. I., Kachanov Y. S.: *Experimental study of resonant interaction of modulated waves in a non self-similar boundary layer*, 7th IUTAM Symposium on Laminar-Turbulent Transition, KTH Stockholm. 22-26.06.2009
- de Paula I. B., Würz W., Medeiros M. A. F.: *Effect of a single three-dimensional roughness element on the boundary layer transition*, 7th IUTAM Symposium on Laminar-Turbulent Transition, KTH Stockholm. 22-26.06.2009
- de Paula, I.B., Würz, W., Krämer, E., Borodulin, V.I., Kachanov, Y.S. Experimental study of weakly non-linear interactions of Tollmien-Schlichting waves in a non self-similar boundary layer. 14th STAB Workshop - Göttingen. 11-12 November 2009, pp. 64-65.
- M.Kamruzzaman, A. Wolf, D. Bekiropoulos, Th. Lutz, A. Herrig, W. Wuerz and E. Krämer: *Study of Turbulent Boundary Layer Wall Pressure Fluctuations Spectrum Models for Trailing-edge Noise Prediction*, Submitted to 15th Int. Conf. on the Methods of Aerophysical Research (ICMAR 2010), Akademgorodok, Novosibirsk Russia, 1-6 Nov., 2010
- de Paula, I.B., Würz, W., Krämer, E., Borodulin, V.I., Kachanov, Y.S. Production of Seeds for Subharmonic Resonance in the Evolution of Modulated T-S waves on an Airfoil Boundary Layer. 8th Euromech Fluid Mechanics Conference. September 13 - 16, 2010. Bad-Reichenhall, Germany.
- de Paula, I.B., Würz, W., Krämer, E., Borodulin, V.I., Kachanov, Y.S. Generation of seeds for subharmonic resonances in an airfoil boundary layer transition initiated by modulated TS waves. XV International Conference on Methods of Aerophysical Research. November 1 - 6, 2010. Novosibirsk: ITAM SB RAS 2010.

10. Sponsored Research Activities

- Grant of the German Foundation for Basic Research (DFG): '*Experimental investigation of laminar separation bubbles*', AL 242/1-3, 1986 - 1988, (Participant in the project)
- Grant of the German Foundation for Basic Research (DFG): '*Experimental investigation of the receptivity of two dimensional boundary layers*', Wa 424/16, 1996 - 2002, (Head of the project)
- Grant of the 'Forschungsschwerpunktprogramm Baden Württemberg, *Intelligenter Tragflügel für zukünftige Flugzeuggenerationen*', (2001-2003) (Participant in the project)
- Grant of the European Commission: '*DATA, Design and Testing of Acoustically Optimized Airfoils for Wind Turbines*' Non-Nuclear Energy Program, JOR3-CT98-0248, 1998 - 2001, (Participant in the project)
- Grant of the German Foundation for Basic Research (DFG): '*Verbundvorhaben SWING, Numerische Aeroakustik für Verkehrsflugzeuge*', Wa 424/17, 1997 - 2000, (Participant in the project)
- Grant of the German Foundation for Basic Research (DFG): '*Verbundvorhaben SWING+, Numerische Aeroakustik für Verkehrsflugzeuge*', Wa 424/18, 2000 - 2003, (Participant in the project)
- International grant of the German Foundation for Basic Research (DFG) together with the Russian Foundation of Basic Research (RFBR): '*Experimental, theoretical and numerical investigation of resonant interactions of TS-instabilities in a boundary layer with variable pressure gradient*', Wu 265/1-1, 2003 - 2005, (Head of the project from German side)
- International grant of the European Commission: '*SIROCCO, Silent Rotors by Acoustic Optimisation*', ENK5-CT-2002-00702, 2003-2006 (Participant in the project)
- International grant of the German Foundation for Basic Research (DFG) together with the Russian Foundation of Basic Research (RFBR): '*Akustische Messverfahren für den Einsatz in Windkanälen mit hohem Hintergrundlärmpegel*', Wu 265/2-1, 2005 - 2008, (Head of the project from German side)
- Integrated EU-project UPWIND, FP6-2004-Energy-3, *Integrated Wind Turbine Design*, 2005-2010 (Participant in the project)
- International grant of the German Federal Ministry of Environment, Nature Conservation and Nuclear Safety (BMU) together with Ministry of Science and Technology Israel: *Active flow control noise reduction*, 2009-2011, (Participant in the project)
- International grant of the German Foundation for Basic Research (DFG) together with the Russian Foundation of Basic Research (RFBR): '*Nichtlineare Stadien der Transition in einer verzögerten Flügel-Grenzschichtströmung bei kontrolliertem, kontinuierlichen und bei natürlichem Störpektrum*', Wu 265/3-1, 2007 - 2010, (Head of the project from German side)
- Collaborated EU-project RECEPT, FP7-AAT-2010-RTD-1: *RECEPTivity and amplitude-based transition prediction*, 2010-2015 (Participant in the project)
- Grant of the German Foundation for Basic Research (DFG): *Interaction of a laminar boundary layer with roughness elements in the close vicinity of an airfoil leading edge*, WU265/4-1, 2010 - present, (Head of the project)