



Professor Gert H. M. van der Heijden

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Center for Nonlinear Dynamics and Its Applications
Department of Civil, Environmental and Geomatic Engineering
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Research Interests:

Generally the geometrically exact description and analysis of slender structures in constrained environments.

1. Nonlinear mechanics of slender elastic structures, both 1D (rods, strings) and 2D (strips, ribbons): post-buckling behaviour, large deformations, (multi-pulse) localisation, static and dynamical stability, bifurcation, constrained deformation (self-contact and surface contact), interaction, discontinuities (kinks), writhing, whirling, transport, ply formation, multi-strand structures, boundary layers, topological properties such as link and writhe. Applications both in engineering (pipe lay, twisted cables, (electrodynamical) space tethers, drill strings, wire rope, rotated and transported textile yarn, nanotube junctions) and in biology (supercoiled DNA, deformations under screened electrostatic interactions, cholesterol ribbons, plied proteins, collagen fibres).
2. Constrained variational calculus, conjugate point theory, variational inequalities, non-smooth mechanical systems
3. Hamiltonian mechanics, integrability, Melnikov theory
4. Computational (numerical as well as analytical) dynamical systems: normal forms, (homoclinic) bifurcations
5. Numerical continuation and bifurcation analysis, computer software
6. Nonlinear rotordynamics, coupled oscillators, chaotic dynamics

Academic Biography:

First degree ('doctorandus', MSc) in theoretical physics, University of Utrecht (1988)
PhD in mathematics, University of Utrecht (1994)

EU Human Capital and Mobility Fellowship, Centre for Nonlinear Dynamics, UCL (1995-1997)
EPSRC Research Fellow, Centre for Nonlinear Dynamics, UCL (1997-1999)
Research Officer, Department of Mathematics, University of Queensland, Brisbane, Australia (October 1998 - January 1999)
Royal Society University Research Fellow (October 1999 - September 2007)
Visiting Scholar, School of Mathematics and Statistics, The University of Sydney, Australia (June - July 2003)
UCL Principal Research Fellow (October 2005 - September 2008)
Honorary Senior Research Fellow, Department of Mathematics, UCL (since October 2006)
Honorary Professor, Lanzhou Jiaotong University, China (since June 2007)
Reader in Nonlinear Dynamics, Department of Civil, Environmental and Geomatic Engineering, UCL (October 2008 - September 2010)
Professor of Nonlinear Dynamics, Department of Civil, Environmental and Geomatic Engineering, UCL (October 2010 - present)

Collaborators:

Alan Champneys (Bristol) (localisation in twisted rods, homoclinic bifurcation and continuation)
Bernard Coleman (Rutgers) (DNA in ionic solution)
Barrie Fraser (Sydney) (whirling and transported rods and textile yarns, asymptotic analysis)
Mike Horton (UCL) (collagen nanofibres and fibrillogenesis)
Alexei Kornyshev (Imperial) (DNA-DNA interaction and supercoiling)
John Maddocks (Lausanne) (variational methods for geometrically constrained rods)
Sébastien Neukirch (Paris) (multi-strand plies, DNA supercoiling)
Mark Peletier (Eindhoven) (global energy minimisers, self-contacting rods, Link-Twist-Writhe)
Eugene Starostin (UCL) (geometry and mechanics of strips, plies and packings)
Michael Thompson (UCL) (structural localisation, DNA supercoiling)
Kazuyuki Yagasaki (Hiroshima) (multi-pulse homoclinic orbits, spatial chaos, Melnikov analysis)
CSIRO, Textile & Fibre Technology Division (Geelong) (plied and spun textile fibres, experiments)

Publications:

G.H.M. van der Heijden, Bifurcation and chaos in drillstring dynamics, *Chaos, Solitons & Fractals* 3, 219-247 (1993).

G.H.M. van der Heijden, Resonant responses and chaos in nonlinear drillstring dynamics, in *Proc. of the Seventh European Conference on Mathematics in Industry*, 2-6 March 1993, Montecatini Terme, Italy, A. Fasano, M. Primicerio (eds) (Teubner, Stuttgart, 1994), pp. 347-354.

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A.R. Champneys, G.H.M. van der Heijden, J.M.T. Thompson, Spatially complex localization after one-twist-per-wave equilibria in twisted circular rods with initial curvature, *Phil. Trans. R. Soc. Lond. A* 355, 2151-2174 (1997).

G.H.M. van der Heijden, A.R. Champneys, J.M.T. Thompson, The spatial complexity of localised buckling in rods with non-circular cross-section, *SIAM J. Appl. Math.* 59, 198-221 (1999).

G.H.M. van der Heijden, J.M.T. Thompson, Lock-on to tape-like behaviour in the torsional buckling of anisotropic rods, *Physica D* 112, 201-224 (1998).

J.M.T. Thompson, G.H.M. van der Heijden, Homoclinic orbits, spatial chaos and localized buckling, in Proc. of the IUTAM Symposium on New Applications of Nonlinear and Chaotic Dynamics in Mechanics, 27 July - 1 August 1997, Cornell University, Ithaca, New York, USA, F.C. Moon (ed.), Solid Mechanics and its Applications, Vol. 63 (Kluwer, Dordrecht, 1999), pp. 127-138.

J.M.T. Thompson, G.H.M. van der Heijden, A.R. Champneys, Twisting, writhing and buckling of pipelines, Proceedings of the 21st annual Offshore Pipeline Technology Conference (OPT '98), 23-24 February 1998, The Holmenkollen Park Hotel Rica, Oslo, Norway (IBC UK Conferences, London, 1998).

G.H.M. van der Heijden, A.R. Champneys, J.M.T. Thompson, Spatially complex localisation in twisted elastic rods constrained to lie in the plane, *J. Mech. Phys. Solids* 47, 59-79 (1999).

G.H.M. van der Heijden, J.M.T. Thompson, Helical and localised buckling in twisted rods: a unified analysis of the symmetric case, *Nonlinear Dynamics* 21, 71-99 (2000).

G.H.M. van der Heijden, Bifurcation sequences in the interaction of resonances in a model deriving from nonlinear rotordynamics: the zipper, *Dynamics and Stability of Systems (now Dynamical Systems)* 15, 159-183 (2000).

D.M. Stump, G.H.M. van der Heijden, Matched asymptotic expansions for bent and twisted rods: applications for cable and pipeline laying, *J. Eng. Math.* 38, 13-31 (2000).

D.M. Stump, A.R. Champneys, G.H.M. van der Heijden, The torsional buckling and writhing of a simply supported rod hanging under gravity, *Int. J. Solids and Struct.* 38, 795-813 (2001).

G.H.M. van der Heijden, The static deformation of a twisted elastic rod constrained to lie on a cylinder, *Proc. R. Soc. Lond. A* 457, 695-715 (2001).

D.M. Stump, G.H.M. van der Heijden, Birdcaging and the collapse of rods and cables in fixed-grip compression, *Int. J. Solids Struct.* 38, 4265-4278 (2001).

S. Neukirch, J.M.T. Thompson, G.H.M. van der Heijden, Filaments enroulées en paires torsadées: application aux plasmides d'A.D.N., in *Compte-rendus de la 4^{ème} Rencontre du Non Linéaire*, 15-16 March 2001, Institut Henri Poincaré, Paris, Y. Pomeau, R. Ribotta (eds) (Non Linéaire Publications, Orsay, 2001), pp. 189-194.

G.H.M. van der Heijden, J.M.T. Thompson, The chaotic instability of a slowly spinning asymmetric top, *Mathematical and Computer Modelling* 36, 359-369 (2002) (download preprint, 954 K).

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J.M.T. Thompson, G.H.M. van der Heijden, S. Neukirch, Supercoiling of DNA plasmids: mechanics of the generalized ply, *Proc. R. Soc. Lond. A* 458, 959-985 (2002).

S. Neukirch, G.H.M. van der Heijden, J.M.T. Thompson, Writhing instabilities of twisted rods: from infinite to finite length, *J. Mech. Phys. Solids* 50, 1175-1191 (2002).

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S. Neukirch, G.H.M. van der Heijden, Geometry and mechanics of uniform n-ply: from engineering ropes to biological filaments, *Journal of Elasticity* 69, 41-72 (2002).

G.H.M. van der Heijden, W.B. Fraser, Helical collapse of a whirling elastic rod forced to lie on a cylinder, *ASME J. Appl. Mech.* 70, 771-774 (2003)

G.H.M. van der Heijden, J.M.T. Thompson, S. Neukirch, A variational approach to loaded ply structures, *Journal of Vibration and Control* 9, 175-185 (2003) (download preprint, 1024 K).

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G.H.M. van der Heijden, A robust variational formulation for a rod subject to inequality constraints: a simple model for a drill string, in *Complementarity, Duality and Symmetry in Nonlinear Mechanics: Proceedings of*

the IUTAM Symposium, D.Y. Gao (ed.), *Advances in Mechanics and Mathematics*, Vol. 6 (Kluwer, Dordrecht, 2004), pp. 313-325.

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V.G.A. Goss, G.H.M. van der Heijden, J.M.T. Thompson, S. Neukirch, Experiments on snap buckling, hysteresis and loop formation in twisted rods, *Experimental Mechanics* 45, 101-111 (2005).

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G.H.M. van der Heijden, M.A. Peletier, R. PlanquÈ, Self-contact for rods on cylinders, *Arch. Rat. Mech. Anal.* 182, 471-511 (2006).

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Laurent Bozec, Gert van der Heijden, Michael Horton, Collagen fibrils: nanoscale ropes, *Biophysical Journal* 92, 70-75 (2007).

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G.H.M. van der Heijden, W.B. Fraser, Bifurcation and stability of a whirling transported thread, in *Proc. of EUROMECH Colloquium 483, Geometrically Non-linear Vibrations of Structures*, 9-11 July 2007, Porto, Portugal, P. Ribeiro, M. Amabili (eds) (DEMEGI - FEUP, University of Porto, Portugal, 2007), pp. 221-224,

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E.L. Starostin, G.H.M. van der Heijden, The shape of a Möbius strip, *Nature Materials* 6, 563-567 (2007).

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W.B. Fraser, G.H.M. van der Heijden, On the theory of localised snarling instabilities in false-twist yarn processes, *Journal of Engineering Mathematics* 61, 81-95 (2008).

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P. Ribeiro, G.H.M. van der Heijden, Elasto-plastic and geometrically nonlinear vibrations of beams by the p-version finite element method, *Journal of Sound and Vibration* 325, 321-337 (2009).

E.L. Starostin, G.H.M. van der Heijden, Cascade unlooping of a low-pitch helical spring under tension, *Journal of the Mechanics and Physics of Solids* 57, 959-969 (2009).

E.L. Starostin, G.H.M. van der Heijden, Force and moment balance equations for geometric variational problems on curves, *Physical Review E* 79, 066602 (2009).

D. Sinden, G.H.M. van der Heijden, Spatial chaos of an extensible conducting rod in a uniform magnetic field, *Journal of Physics A: Mathematical and Theoretical* 42, 375207 (2009).

A.P. Korte, G.H.M. van der Heijden, Curvature-induced electron localization in developable Möbius-like nanostructures, *J. Phys.: Condens. Matter* 21, 495301 (2009).

D.G. Phillips, C.-D. Tran, W.B. Fraser, G.H.M. van der Heijden, Torsional properties of staple fibre plied yarns, *The Journal of the Textile Institute* 101, 595-612 (2010).

J. Valverde, G.H.M. van der Heijden, Magnetically-induced buckling of a whirling conducting rod with applications to electrodynamic space tethers, *Journal of Nonlinear Science* 20, 309-339 (2010).

A.P. Korte, G.H.M. van der Heijden, A new triangular buckling pattern of twisted inextensible sheets, in *Advances and Trends in Structural Engineering, Mechanics and Computation: Proceedings of the Fourth International Conference on Structural Engineering, Mechanics and Computation (SEMC 2010)*, 6-8 September 2010, Cape Town, South Africa, A. Zingoni (ed.) (CRC Press/Balkema, Leiden, The Netherlands, 2010), pp. 545-548, ISBN 978-0-415-58472-2.

A.P. Korte, E.L. Starostin, G.H.M. van der Heijden, Triangular buckling patterns of twisted inextensible strips, *Proceedings of the Royal Society A* 467, 285-303 (2011).

D. Sinden, G.H.M. van der Heijden, Localisation of a twisted conducting rod in a uniform magnetic field: the Hamiltonian-Hopf-Hopf bifurcation, submitted to *Physica D*.

E.L. Starostin, G.H.M. van der Heijden, An elastic two-strand ply theory, in *Proc. of the 7th European Nonlinear Dynamics Conference (ENOC 2011)*, 24-29 July 2011, Rome, Italy, D. Bernardini, G. Rega, F. Romeo (eds) (Department of Structural and Geotechnical Engineering, Sapienza University of Rome, 2011), 2 pages, ISBN 978-88-906234-2-4.

G.H.M. van der Heijden, D. Sinden, Localisation of a twisted conducting rod in a uniform magnetic field: the Hamiltonian-Hopf-Hopf bifurcation, in *Proc. of the 7th European Nonlinear Dynamics Conference (ENOC 2011)*, 24-29 July 2011, Rome, Italy, D. Bernardini, G. Rega, F. Romeo (eds) (Department of Structural and

Geotechnical Engineering, Sapienza University of Rome, 2011), 2 pages, ISBN 978-88-906234-2-4.

D. Sinden, G.H.M. van der Heijden, The buckling of magneto-strictive Cosserat rods, in Proc. of the 7th European Nonlinear Dynamics Conference (ENOC 2011), 24-29 July 2011, Rome, Italy, D. Bernardini, G. Rega, F. Romeo (eds) (Department of Structural and Geotechnical Engineering, Sapienza University of Rome, 2011), 2 pages, ISBN 978-88-906234-2-4.

G.H.M. van der Heijden, K. Yagasaki, Nonintegrability of an extensible conducting rod in a uniform magnetic field, *Journal of Physics A: Mathematical and Theoretical* 44, 495101 (2011).

E.L. Starostin, G.H.M. van der Heijden, Comment on "Statistical mechanics of developable ribbons", *Physical Review Letters* 107, 239801 (2011).

J. Valverde, G.H.M. van der Heijden, Helical buckling of a whirling conducting rod in a uniform magnetic field, *International Journal of Non-Linear Mechanics* 47, 38-53 (2012).

J.M.T. Thompson, M. Silveira, G.H.M. van der Heijden, M. Wiercigroch, Helical post-buckling of a rod in a cylinder: with applications to drill-strings, *Proceedings of the Royal Society A* 468, 1591-1614 (2012).

E.L. Starostin, G.H.M. van der Heijden, Equilibria of elastic knots, in *Book of Abstracts of the 8th European Solid Mechanics Conference (ESMC 2012)*, 9-13 July 2012, Graz, Austria, G.A. Holzapfel, R.W. Ogden (eds) (European Mechanics Society, 2012), 2 pages, ISBN 978-3-85125-223-1.

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G.H.M. van der Heijden, K. Yagasaki, Horseshoes for the nearly symmetric heavy top, *Z. Angew. Math. Phys. (ZAMP)*.

E.L. Starostin, G.H.M. van der Heijden, Theory of equilibria of elastic 2-braids with interstrand interaction, submitted.

E.L. Starostin, G.H.M. van der Heijden, Tightening elastic torus knots $(n, 2)$, submitted.

D.J. Lee, R. Cortini, A.P. Korte, E.L. Starostin, G.H.M. van der Heijden, A.A. Kornyshev, Chiral effects in dual-DNA braiding, submitted.

Special Issues:

Solitary Waves and Localisation Phenomena in Elastic Structures, J.M.T. Thompson & G.H.M. van der Heijden (eds), *Nonlinear Dynamics* 21(1), January 2000.

Modern Trends in Theoretical and Applied Mechanics: A Special Issue in Honour of Michael Thompson, G.H.M. van der Heijden (ed.), *Nonlinear Dynamics* 43(1-2), January 2006.

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