References

1. Ackerberg, R.C., O'Malley, R.E.: Boundary layer problems exhibiting resonance. Stud. Appl. Math. **49**, 277–295 (1970)
2. Balser, W.: Formal Power Series and Linear Systems of Meromorphic Ordinary Differential Equations. Springer, New York (2000)
3. Benoît, É., Callot, J.-L., Diener, F., Diener, M.: Chasse au canard. Collect. Math. **31**, 37–119 (1981)
4. Benoît, É., El Hamidi, A., Fruchard, A.: On combined asymptotic expansions in singular perturbations. Electron. J. Diff. Equat. **51**, 1–27 (2002)
5. Benoît, É., Fruchard, A., Schäfke, R., Wallet, G.: Solutions surstables des équations différentielles complexes lentes-rapides à point tournant. Ann. Fac. Sci. Toulouse Math. VII **4**, 627–658 (1998)
6. Benoît, É., Fruchard, A., Schäfke, R., Wallet, G.: Overstability: Toward a global study. C. R. Acad. Sci. Paris I **326**, 873–878 (1998)
7. Bonckaert, P., De Maesschalck, P., Gevrey normal forms of vector fields with one zero eigenvalue. J. Math. Anal. Appl. **344**, 301–321 (2008)
8. Canalis-Durand, M., Mozo-Fernandez, J., Schäfke, R.: Monomial summability and doubly singular differential equations. J. Differ. Equat. **233**, 485–511 (2007)
9. Canalis-Durand, M., Ramis, J.-P., Schäfke, R., Sibuya, Y.: Gevrey solutions of singularly perturbed differential equations. J. Reine Angew. Math. **518**, 95–129 (2000)
10. De Maesschalck, P.: On maximum bifurcation delay in real planar singularly perturbed vector fields. Nonlinear Anal. **68**, 547–576 (2008)
11. De Maesschalck, P.: Ackerberg-O'Malley resonance in boundary value problems with a turning point of any order. Commun. Pure Appl. Anal. **6**, 311–333 (2007)
12. De Maesschalck, P.: Gevrey properties of real planar singularly perturbed systems. J. Differ. Equat. **238**, 338–365 (2007)
13. De Maesschalck, P., Dumortier, F.: Canard solutions at non-generic turning points. Trans. Am. Math. Soc. **358**, 2291–2334 (2006)
14. Diener, M.: Regularizing microscopes and rivers. SIAM J. Math. Anal. **25**, 148–173 (1994)
15. Dorodnitsyn, A.A.: Asymptotic solution of the Van der Pol equation. Priklad. Mat. Mekh. **11**, 313–328 (1947) (in russian)
16. Dumortier, F., Roussarie, R.: Canard cycles and center manifolds. Memoir. Am. Math. Soc. 577, 1996
17. Eckhaus, W.: Asymptotic analysis of singular perturbations. Studies in Mathematics and its Applications, vol. 9. North-Holland, Amsterdam (1979)
18. Erdélyi, A.: Singular perturbations of boundary value problems involving ordinary differential equations. J. Soc. Indust. Appl. Math. **11**, 105–116 (1963)

A. Fruchard and R. Schäfke, *Composite Asymptotic Expansions*, Lecture Notes in Mathematics 2066, DOI 10.1007/978-3-642-34035-2,

19. Fenichel, N.: Geometric singular perturbation theory for ordinary differential equations. J. Differ. Equat. **31**, 53–98 (1979)
20. Forget, T.: Points tournants dégénérés, Thèse de Doctorat, Université de La Rochelle, 2007
21. Forget, T.: Solutions canards en des points tournants dégénérés. Ann. Fac. Sci. Toulouse Math. **16**, 799–816 (2007)
22. Forget, T.: Asymptotic study of planar canard solutions. Bull. Belg. Math. Soc. Simon Stevin **15**, 809–824 (2008)
23. Fraenkel, L.E.: On the method of matched asymptotic expansions. Proc. Cambridge Philos. Soc. **65**, 209–284 (1969)
24. Fruchard, A., Schäfke, R.: Exceptional complex solutions of the forced Van der Pol equation. Funkcialaj Ekvacioj **42**, 201–223 (1999)
25. Fruchard, A., Schäfke, R.: Overstability and resonance. Ann. Inst. Fourier Grenoble **53**, 227–264 (2003)
26. Fruchard, A., Schäfke, R.: A survey of some results on overstability and bifurcation delay. Discrete Cont. Dyn. Syst. S **2**, 931–965 (2009)
27. Fruchard, A., Schäfke, R.: De nouveaux développements asymptotiques combinés pour la perturbation singulière. Actes du Colloque à la mémoire d'Emmanuel Isambert Publications Univ. Paris **13**, 125–161 (2012)
28. Fruchard, A., Schäfke, R.: Composite asymptotic expansions and turning points of singularly perturbed ordinary differential equations. C. R. Math. Acad. Sci. **348**, 1273–1277 (2010)
29. Gautheron, V., Isambert, E.: Finitely differentiable ducks and finite expansions. In: Benoît, E. (ed.) Dynamic Bifurcations, Lect. Notes Math., vol. 1493, pp. 40–56. Springer, New York (1991)
30. Van Gils, S., Krupa, M., Szmolyan, P.: Asymptotic expansions using blow-up Z. Angew. Math. Phys. **56**, 369–397 (2005)
31. Hek, G.: Geometric singular perturbation theory in biological practice. J. Math. Biol. **60**, 347–386 (2010)
32. Isambert, E.: Nonsmooth ducks and regular perturbations of rivers, I and II. J. Math. Anal. Appl. **200**, 14–33 and 289–306 (1996)
33. Jones, C.K.R.T.: Geometric singular perturbation theory. In: Dynamical Systems, Lect. Notes Math., vol. 1609. Springer, New York (1995)
34. Kaplun, S., Lagerstrom, P.A.: Asymptotic expansions of Navier-Stokes solutions for small Reynolds numbers. J. Math. Mech. **6**, 585–593 (1957)
35. Kevorkian, J., Cole, J.D.: Perturbation methods in applied mathematics. Applied Mathematical Sciences, vol. 34. Springer, New York (1981)
36. Kopell, N.: A geometric approach to boundary layer problems exhibiting resonance. SIAM J. Appl. Math. **37**, 436–458 (1979)
37. Kopell, N.: The singularly perturbed turning-point problem: a geometric approach. In: Singular perturbations and asymptotics, Proc. Adv. Sem., Math. Res. Center, University of Wisconsin, Madison, Wisconsin (1980) 173–190
38. Krupa, M., Szmolyan, P.: Relaxation oscillation and canard explosion. J. Differ. Equat. **174**, 312–368 (2001)
39. Krupa, M., Szmolyan, P.: Extending geometric singular perturbation theory to nonhyperbolic points-fold and canard points in two dimensions. SIAM J. Math. Anal., **33**, 286–314 (2001)
40. Lagerstrom, P.A.: Matched asymptotic expansions: ideas and techniques. Applied Mathematical Sciences, vol. 76. Springer, New York (1988)
41. Lobry, C.: Dynamic bifurcations. In: Benoît, E. (ed.) Dynamic Bifurcations, Lect. Notes Math., vol. 1493, pp. 1–13. Springer, New York (1991)
42. Matzinger, É.: Étude d'équations différentielles ordinaires singulièrement perturbées au voisinage d'un point tournant. Thesis, Preprint IRMA 2000/53, Strasbourg (2000)
43. Matzinger, É.: Étude des solutions surstables de l'équation de Van der Pol. Ann. Fac. Sci. Toulouse **10**, 713–744 (2001)
44. Matzinger, É.: Asymptotic behaviour of solutions near a turning point: the example of the brusselator equation. J. Differ. Equat. **220**, 478–510 (2006)

45. Mischenko, E.F., Rozov, N.Ch.: Differential Equations with Small Parameters and Relaxation Oscillations. Plenum Press, New York and London (1980)
46. O'Malley, R.E.: Singular perturbation methods for ordinary differential equations. Applied Mathematical Sciences, vol. 89. Springer, New York (1991)
47. Panazzolo, D.: On the existence of canard solutions. Publ. Mat. **44**, 503–592 (2000)
48. Ramis, J.-P.: Dévissage Gevrey. Astérisque **59–60**, 173–204 (1978)
49. Ramis, J.-P.: Les séries k-sommables et leurs applications. In: Complex Analysis, Microlocal Calculus and Relativistic Quantum Theory, Lect. Notes Physics, vol. 126, pp. 178–199. Springer, New York (1980)
50. Sibuya, Y.: Gevrey property of formal solutions in a parameter. In: Asymptotic and computational analysis (Winnipeg, MB, 1989). Lecture Notes in Pure and Appl. Math., vol. 124, pp. 393–401. Dekker, New York (1990)
51. Sibuya, Y.: Linear differential equations in the complex domain. Problems of Analytic Continuation. Am. Math. Soc., Providence (RI) (1990)
52. Sibuya, Y.: Uniform simplification in a full neighborhood of a transition point. Memoi. Am. Math. Soc. **149** (1974)
53. Sibuya, Y.: A theorem concerning uniform simplification at a transition point and a problem of resonance. SIAM J. Math. Anal. **12**(5), 653–668 (1981)
54. Skinner, L.A.: Singular Perturbation Theory. Springer, New York (2011)
55. Skinner, L.A.: Uniform solution of boundary layer problems exhibiting resonance. SIAM J. Appl. Math. **47**, 225–231 (1987)
56. Skinner, L.A.: Matched expansion solutions of the first-order turning point problem. SIAM J. Math. Anal. **25**, 1402–1411 (1994)
57. Skinner, L.A.: A class of singularly perturbed singular Volterra integral equations. Asymptot. Anal. **22**, 113–127 (2000)
58. Szmolyan, P., Wechselberger, M.: Canards in R3. J. Differ. Equat. **177**, 419–453 (2001)
59. Vasil'eva, A.B., Butuzov, V.F.: Asymptotic Expansions of the Solutions of Singularly Perturbed Equations. Izdat. "Nauka", Moscow (1973) (in Russian)
60. Wallet, G.: Surstabilité pour une équation différentielle analytique en dimension un. Ann. Inst. Fourier **40**, 557–595 (1990)
61. Wasow, W.: Asymptotic Expansions for Ordinary Differential Equations. Interscience, New York (1965)
62. Wasow, W.: Linear Turning Point Theory. Springer, New York (1985)

Index

Symbols

A

B

A. Fruchard and R. Schäfke, *Composite Asymptotic Expansions*, Lecture Notes in Mathematics 2066, DOI 10.1007/978-3-642-34035-2,

M

O

Q

R

S

T

U

V

W

LECTURE NOTES IN MATHEMATICS Springer

Edited by J.-M. Morel, B. Teissier; P.K. Maini

Editorial Policy (for the publication of monographs)

1. Lecture Notes aim to report new developments in all areas of mathematics and their applications - quickly, informally and at a high level. Mathematical texts analysing new developments in modelling and numerical simulation are welcome.
   Monograph manuscripts should be reasonably self-contained and rounded off. Thus they may, and often will, present not only results of the author but also related work by other people. They may be based on specialised lecture courses. Furthermore, the manuscripts should provide sufficient motivation, examples and applications. This clearly distinguishes Lecture Notes from journal articles or technical reports which normally are very concise. Articles intended for a journal but too long to be accepted by most journals, usually do not have this "lecture notes" character. For similar reasons it is unusual for doctoral theses to be accepted for the Lecture Notes series, though habilitation theses may be appropriate.

2. Manuscripts should be submitted either online at www.editorialmanager.com/lnm to Springer's mathematics editorial in Heidelberg, or to one of the series editors. In general, manuscripts will be sent out to 2 external referees for evaluation. If a decision cannot yet be reached on the basis of the first 2 reports, further referees may be contacted: The author will be informed of this. A final decision to publish can be made only on the basis of the complete manuscript, however a refereeing process leading to a preliminary decision can be based on a pre-final or incomplete manuscript. The strict minimum amount of material that will be considered should include a detailed outline describing the planned contents of each chapter, a bibliography and several sample chapters.
   Authors should be aware that incomplete or insufficiently close to final manuscripts almost always result in longer refereeing times and nevertheless unclear referees' recommendations, making further refereeing of a final draft necessary.
   Authors should also be aware that parallel submission of their manuscript to another publisher while under consideration for LNM will in general lead to immediate rejection.

3. Manuscripts should in general be submitted in English. Final manuscripts should contain at least 100 pages of mathematical text and should always include

   – a table of contents;
   – an informative introduction, with adequate motivation and perhaps some historical remarks: it should be accessible to a reader not intimately familiar with the topic treated;
   – a subject index: as a rule this is genuinely helpful for the reader.

   For evaluation purposes, manuscripts may be submitted in print or electronic form (print form is still preferred by most referees), in the latter case preferably as pdf- or zipped psfiles. Lecture Notes volumes are, as a rule, printed digitally from the authors' files. To ensure best results, authors are asked to use the LaTeX2e style files available from Springer's web-server at:

   ftp://ftp.springer.de/pub/tex/latex/svmonot1/ (for monographs) and
   ftp://ftp.springer.de/pub/tex/latex/svmultt1/ (for summer schools/tutorials).

Additional technical instructions, if necessary, are available on request from lnm@springer.com.

4. Careful preparation of the manuscripts will help keep production time short besides ensuring satisfactory appearance of the finished book in print and online. After acceptance of the manuscript authors will be asked to prepare the final LaTeX source files and also the corresponding dvi-, pdf- or zipped ps-file. The LaTeX source files are essential for producing the full-text online version of the book (see http://www.springerlink.com/openurl.asp?genre=journal&issn=0075-8434 for the existing online volumes of LNM). The actual production of a Lecture Notes volume takes approximately 12 weeks.

5. Authors receive a total of 50 free copies of their volume, but no royalties. They are entitled to a discount of 33.3 % on the price of Springer books purchased for their personal use, if ordering directly from Springer.

6. Commitment to publish is made by letter of intent rather than by signing a formal contract. Springer-Verlag secures the copyright for each volume. Authors are free to reuse material contained in their LNM volumes in later publications: a brief written (or e-mail) request for formal permission is sufficient.

Addresses:

Professor J.-M. Morel, CMLA,
École Normale Supérieure de Cachan,
61 Avenue du Président Wilson, 94235 Cachan Cedex, France
E-mail: morel@cmla.ens-cachan.fr

Professor B. Teissier, Institut Mathématique de Jussieu,
UMR 7586 du CNRS, Équipe "Géométrie et Dynamique",
175 rue du Chevaleret
75013 Paris, France
E-mail: teissier@math.jussieu.fr

For the "Mathematical Biosciences Subseries" of LNM:

Professor P. K. Maini, Center for Mathematical Biology,
Mathematical Institute, 24-29 St Giles,
Oxford OX1 3LP, UK
E-mail : maini@maths.ox.ac.uk

Springer, Mathematics Editorial, Tiergartenstr. 17,
69121 Heidelberg, Germany,
Tel.: +49 (6221) 4876-8259

Fax: +49 (6221) 4876-8259
E-mail: lnm@springer.com