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## Publications

### Publications in Refereed Journals and Proceedings.

- (1) A. Kriegl, M. Losik, P.W. Michor, A. Rainer, *Lifting smooth curves over invariants for representations of compact Lie groups, II*, J. Lie Theory **15** (2005), No. 1, 227–234. arXiv:math.RT/0402222.
- (2) A. Kriegl, M. Losik, P.W. Michor, A. Rainer, *Lifting smooth curves over invariants for representations of compact Lie groups, III*, J. Lie Theory **16** (2006), No. 3, 579–600. arXiv:math.RT/0504101.
- (3) S. Hochgerner, A. Rainer, *Singular Poisson reduction of cotangent bundles*, Rev. Mat. Complut. **19** (2006), No. 2, 431–466. [https://doi.org/10.5209/rev\\_REMA.2006.v19.n2.16607](https://doi.org/10.5209/rev_REMA.2006.v19.n2.16607). arXiv:math.SG/0508455.
- (4) M. Losik, A. Rainer, *Choosing roots of polynomials with symmetries smoothly*, Rev. Mat. Complut. **20** (2007), No. 2, 267–291. [https://doi.org/10.5209/rev\\_REMA.2007.v20.n2.16475](https://doi.org/10.5209/rev_REMA.2007.v20.n2.16475). arXiv:math.CA/0603660.
- (5) A. Kriegl, M. Losik, P.W. Michor, A. Rainer, *Lifting mappings over invariants of finite groups*, Acta Math. Univ. Comenian. (N.S.) **77** (2008), No. 1, 93–122. arXiv:math.AG/0312030.
- (6) A. Rainer, *Orbit projections as fibrations*, Czechoslovak Math. J. **59** (2009), No. 2, 529–538. <https://doi.org/10.1007/s10587-009-0035-1>. arXiv:math.DG/0610513.
- (7) A. Rainer, *Orbit projections of proper Lie groupoids as fibrations*, Czechoslovak Math. J. **59** (2009), No. 3, 591–594. <https://doi.org/10.1007/s10587-009-0053-z>. arXiv:0712.0706.
- (8) A. Rainer, *Invariant functions in Denjoy–Carleman classes*, Ann. Global Anal. Geom. **35** (2009), No. 3, 249–266. <https://doi.org/10.1007/s10455-008-9135-7>. arXiv:0711.3163.
- (9) A. Kriegl, P.W. Michor, A. Rainer, *The convenient setting for non-quasianalytic Denjoy–Carleman differentiable mappings*, J. Funct. Anal. **256** (2009), No. 11, 3510–3544. <https://doi.org/10.1016/j.jfa.2009.03.003>. arXiv:0804.2995.
- (10) A. Rainer, *Perturbation of complex polynomials and normal operators*, Math. Nachr. **282** (2009), No. 12, 1623–1636. <https://doi.org/10.1002/mana.200910837>. arXiv:math.CA/0611633.
- (11) A. Rainer, *Smooth roots of hyperbolic polynomials with definable coefficients*, Israel J. Math., **184** (2011), No. 1, 157–182. <https://doi.org/10.1007/s11856-011-0063-z>. arXiv:0904.4164.
- (12) A. Kriegl, P.W. Michor, A. Rainer, *The convenient setting for quasianalytic Denjoy–Carleman differentiable mappings*, J. Funct. Anal. **261** (2011), No. 7, 1799–1834. <https://doi.org/10.1016/j.jfa.2011.05.019>. arXiv:0909.5632.
- (13) A. Rainer, *Quasianalytic multiparameter perturbation of polynomials and normal matrices*, Trans. Amer. Math. Soc. **363** (2011), No. 9, 4945–4977. <https://doi.org/10.1090/S0002-9947-2011-05311-0>. arXiv:0905.0837.
- (14) A. Kriegl, P.W. Michor, A. Rainer, *Denjoy–Carleman differentiable perturbation of polynomials and unbounded operators*, Integral Equations Operator Theory **71** (2011), No. 3, 407–416. <https://doi.org/10.1007/s00020-011-1900-5>. arXiv:0910.0155.
- (15) M. Losik, P.W. Michor, A. Rainer, *A generalization of Puiseux’s theorem and lifting curves over invariants*, Rev. Mat. Complut. **25** (2012), No. 1, 139–155. <https://doi.org/10.1007/s13163-011-0062-y>. arXiv:0904.2068.
- (16) A. Rainer, *Lifting quasianalytic mappings over invariants*, Canad. J. Math. **64** (2012), No. 2, 409–428. <https://doi.org/10.4153/CJM-2011-049-0>. arXiv:1007.0836.
- (17) A. Kriegl, P.W. Michor, A. Rainer, *Many parameter Hölder perturbation of unbounded operators*, Math. Ann. **353** (2012), No. 2, 519–522. <https://doi.org/10.1007/s00208-011-0693-9>. arXiv:math.FA/0611506.

- (18) A. Kriegl, M. Losik, P.W. Michor, A. Rainer, *Addendum to: “Lifting smooth curves over invariants for representations of compact Lie groups, III”* [*J. Lie Theory* **16** (2006), No. 3, 579–600.], *J. Lie Theory* **22** (2012), No. 1, 245–249. arXiv:1106.6041.
- (19) A. Rainer, *Perturbation theory for normal operators*, *Trans. Amer. Math. Soc.*, **365** (2013), No. 10, 5545–5577. <https://doi.org/10.1090/S0002-9947-2013-05854-0>. arXiv:1111.4475.
- (20) A. Rainer, *Differentiable roots, eigenvalues, and eigenvectors*, *Israel J. Math.*, **201** (2014), No. 1, 99–122. <https://doi.org/10.1007/s11856-014-0007-5>. arXiv:1211.4124.
- (21) A. Rainer, G. Schindl, *Composition in ultradifferentiable classes*, *Studia Math.*, **224** (2014), No. 2, 97–131. <https://doi.org/10.4046/sm224-2-1>. arXiv:1210.5102.
- (22) A. Kriegl, P.W. Michor, A. Rainer, *An exotic zoo of diffeomorphism groups on  $\mathbb{R}^n$* , *Ann. Global Anal. Geom.* **47** (2015), No. 2, 179–222. <https://doi.org/10.1007/s10455-014-9442-0>. arXiv:1404.7033.
- (23) A. Parusiński, A. Rainer, *A new proof of Bronshtein’s theorem*, *J. Hyperbolic Differ. Equ.*, **12** (2015), No. 4, 671–688. <https://doi.org/10.1142/S0219891615500198>. arXiv:1309.2150.
- (24) A. Kriegl, P.W. Michor, A. Rainer, *The convenient setting for Denjoy–Carleman differentiable mappings of Beurling and Roumieu type*, *Rev. Mat. Complut.*, **28** (2015), No. 3, 549–597. <https://doi.org/10.1007/s13163-014-0167-1>. arXiv:1111.1819.
- (25) A. Rainer, G. Schindl, *Equivalence of stability properties for ultradifferentiable function classes*, *Rev. R. Acad. Cienc. Exactas Fis. Nat. Ser. A Math. RACSAM.*, **110** (2016), No. 1, 17–32. <https://doi.org/10.1007/s13398-014-0216-0>. arXiv:1407.6673.
- (26) A. Parusiński, A. Rainer, *Regularity of roots of polynomials*, *Ann. Sc. Norm. Super. Pisa Cl. Sci. (5)*, **16** (2016), No. 2, 481–517. [https://doi.org/10.2422/2036-2145.201404\\_014](https://doi.org/10.2422/2036-2145.201404_014). arXiv:1309.2151.
- (27) A. Parusiński, A. Rainer, *Lifting differentiable curves from orbit spaces*, *Transform. Groups*, **21** (2016), No. 1, 153–179. <https://doi.org/10.1007/s00031-015-9346-5>. arXiv:1406.2485.
- (28) A. Kriegl, P.W. Michor, A. Rainer, *The exponential law for spaces of test functions and diffeomorphism groups*, *Indag. Math. (N.S.)*, **27** (2016), No. 1, 225–265. <https://doi.org/10.1016/j.indag.2015.10.006>. arXiv:1411.0483.
- (29) A. Rainer, G. Schindl, *On the Borel mapping in the quasianalytic setting*, *Math. Scand.* **121** (2017), No. 2, 293–310. <https://doi.org/10.7146/math.scand.a-97101>. arXiv:1509.05565.
- (30) A. Rainer, G. Schindl, *Extension of Whitney jets of controlled growth*, *Math. Nachr.* **290** (2017), No. 14–15, 2356–2374. <https://doi.org/10.1002/mana.201600321>. arXiv:1607.01206.
- (31) A. Rainer, *Recognizing (ultra)differentiable functions on closed sets*, *Oberwolfach Reports Volume 14* (2017), Issue 2, 1369–1372. <https://doi.org/10.4171/OWR/2017/22>.
- (32) A. Parusiński, A. Rainer, *Optimal Sobolev regularity of roots of polynomials*, *Ann. Sci. Ec. Norm. Super. (4)* **51** (2018), No. 5, 1343–1387. <https://doi.org/10.24033/asens.2376>. arXiv:1506.01512.
- (33) D.N. Nenning, A. Rainer, *On groups of Hölder diffeomorphisms and their regularity*, *Trans. Amer. Math. Soc.* **370** (2018), No. 8, 5761–5794. <https://dx.doi.org/10.1090/tran/7269>. arXiv:1612.03390.
- (34) Piotr T. Chruściel, Erwann Delay, Paul Klinger, with an Appendix by Andreas Kriegl, Peter W. Michor, and Armin Rainer, *Non-singular spacetimes with a negative cosmological constant: V. Boson stars*, *Lett. Math. Phys.* **108** (2018), No. 9, 2009–2030. <https://doi.org/10.1007/s11005-018-1062-3>. arXiv:1708.02878.
- (35) M. Bruveris, P.W. Michor, A. Parusiński, A. Rainer, *Moser’s theorem on manifolds with corners*, *Proc. Amer. Math. Soc.* **146** (2018), No. 11, 4889–4897. <https://doi.org/10.1090/proc/14130>. arXiv:1604.07787.
- (36) A. Rainer, G. Schindl, *On the extension of Whitney ultrajets*, *Studia Math.* **245** (2019), No. 3, 255–287. <https://doi.org/10.4064/sm170906-23-11>. arXiv:1709.00932.
- (37) D.N. Nenning, A. Rainer, *The Trouvé group for spaces of test functions*, *Rev. R. Acad. Cienc. Exactas Fis. Nat. Ser. A Math. RACSAM* **113** (2019), No. 3, 1799–1822. <https://doi.org/10.1007/s13398-018-0581-1>. arXiv:1711.01196.
- (38) A. Rainer, *Arc-smooth functions on closed sets*, *Compos. Math.* **155** (2019), No. 4, 645–680. <https://doi.org/10.1112/S0010437X19007097>. arXiv:1801.08335.
- (39) A. Rainer, *Quasianalytic ultradifferentiability cannot be tested in lower dimensions*, *Bull. Belg. Math. Soc. Simon Stevin*, **26** (2019), No. 4, 505–517. <https://doi.org/10.36045/bbms/1576206353>. arXiv:1810.10767.

- (40) A. Rainer, G. Schindl, *On the extension of Whitney ultrajets, II*, *Studia Math.* **250** (2020), No. 3, 283–295. <https://doi.org/10.4064/sm180903-12-11>. arXiv:1808.10253.
- (41) S. Fördös, D.N. Nenning, A. Rainer, G. Schindl, *Almost analytic extensions of ultradifferentiable functions with applications to microlocal analysis*, *J. Math. Anal. Appl.* **481** (2020), No. 1, 123451, 51 pp. <https://doi.org/10.1016/j.jmaa.2019.123451>. arXiv:1904.07634.
- (42) A. Parusiński, A. Rainer, *Selections of bounded variation for roots of smooth polynomials*, *Selecta Math. (N.S.)* **26** (2020), No. 1, Paper No. 13, 40 pp. <https://doi.org/10.1007/s00029-020-0538-z>. arXiv:1705.10492.
- (43) A. Rainer, *Ultradifferentiable Chevalley theorems and isotropic functions*, *Ann. Mat. Pura Appl. (4)* **200** (2021), No. 2, 491–504. <https://doi.org/10.1007/s10231-020-01003-3>. arXiv:1912.09114.
- (44) A. Rainer, *On the extension of Whitney ultrajets of Beurling type*, *Results Math.* **76** (2021), No. 1, Paper No. 36, 20 pp. <https://doi.org/10.1007/s00025-021-01347-z>. arXiv:2011.02178.
- (45) A. Parusiński, A. Rainer, *Sobolev lifting over invariants*, *SIGMA Symmetry Integrability Geom. Methods Appl.* **17** (2021), Paper No. 037, 31 pp. <https://doi.org/10.3842/SIGMA.2021.037>. arXiv:2003.01967.
- (46) D.N. Nenning, A. Rainer, G. Schindl, *Ultraholomorphic sectorial extensions of Beurling type*, *Ann. Funct. Anal.* **12** (2021), No. 3, Paper No. 45, 20 pp. <https://doi.org/10.1007/s43034-021-00124-x>. arXiv:2012.12332.
- (47) D.N. Nenning, A. Rainer, G. Schindl, *Nonlinear conditions for ultradifferentiability*, *J. Geom. Anal.* **31** (2021), No. 12, 12264–12287. <https://doi.org/10.1007/s12220-021-00718-w>. arXiv:2102.03871.
- (48) A. Rainer, *Roots of Gårding hyperbolic polynomials*, *Proc. Amer. Math. Soc.*, **150** (2022), No. 6, 2433–2446. <https://doi.org/10.1090/proc/15634>. arXiv:2012.01077.
- (49) A. Rainer, *Ultradifferentiable extension theorems: a survey*, *Expo. Math.* **40** (2022), No. 3, 679–757. <https://doi.org/10.1016/j.exmath.2021.12.001>. arXiv:2107.01061.
- (50) D.N. Nenning, A. Rainer, G. Schindl, *Nonlinear conditions for ultradifferentiability: a uniform approach*, *J. Geom. Anal.* **32** (2022), No. 6, Paper No. 171, 18 pp. <https://doi.org/10.1007/s12220-022-00914-2>. arXiv:2109.07795.
- (51) A. Rainer, *Hölder–Zygmund classes on smooth curves*, *Z. Anal. Anwend.* **41** (2022), No. 1–2, 189–209. <https://doi.org/10.4171/zaa/1704>. arXiv:2203.04191.
- (52) D.N. Nenning, A. Rainer, G. Schindl, *On optimal solutions of the Borel problem in the Roumieu case*, *Bull. Belg. Math. Soc. Simon Stevin* **29** (2022), No. 4, 509–531. <https://doi.org/10.36045/j.bbms.220322>. arXiv:2112.08463.
- (53) D.N. Nenning, A. Rainer, G. Schindl, *The Borel map in the mixed Beurling setting*, *Rev. R. Acad. Cienc. Exactas Fis. Nat. Ser. A Math. RACSAM* **117** (2023), No. 1, Paper No. 40, 35 pp. <https://doi.org/10.1007/s13398-022-01372-9>. arXiv:2205.08195.
- (54) A. Rainer, *Quantitative tame properties of differentiable functions with controlled derivatives*, *Nonlinear Anal.* **237** (2023), Paper No. 113372, 27 pp. <https://doi.org/10.1016/j.na.2023.113372>. arXiv:2208.04006.
- (55) A. Rainer, *Arc-smooth functions and cuspidality of sets*, *J. Anal. Math.* **155** (2025), No. 1, 1–41. <https://doi.org/10.1007/s11854-024-0337-0>. arXiv:2112.14163.
- (56) A. Rainer, *On real analytic functions on closed subanalytic domains*, *Arch. Math. (Basel)* **122** (2024), No. 6, 639–650. <https://doi.org/10.1007/s00013-024-01983-1>. arXiv:2311.03014.
- (57) A. Parusiński, A. Rainer, *Uniform extension of definable  $C^{m,\omega}$ -Whitney jets*, *Pacific J. Math.* **330** (2024), No. 2, 317–353. <https://doi.org/10.2140/pjm.2024.330.317>. arXiv:2306.09156.
- (58) A. Rainer, G. Schindl, *Interpolation of derivatives and ultradifferentiable regularity*, *Math. Nachr.* **298** (2025), No. 2, 617–635. <https://doi.org/10.1002/mana.202300567>. arXiv:2312.07020.
- (59) A. Parusiński, A. Rainer, *Perturbation theory of polynomials and linear operators*, *Handbook of Geometry and Topology of Singularities, VII*, Springer Nature (2025), 121–202. [https://doi.org/10.1007/978-3-031-68711-2\\_3](https://doi.org/10.1007/978-3-031-68711-2_3). arXiv:2308.01299.
- (60) A. Parusiński, A. Rainer, *Definable Lipschitz selections for affine-set valued maps*, *Israel J. Math.* (2025), <https://doi.org/10.1007/s11856-025-2795-1>. arXiv:2306.09155.
- (61) A. Rainer, *On spaces of arc-smooth maps*, to appear in *Collect. Math.*, arXiv:2503.07023.

**Preprints and Work in Progress.**

- A. Parusiński and A. Rainer, *Continuity of the solution map for hyperbolic polynomials*, arXiv:2410.01321.
- A. Parusiński and A. Rainer, *On the continuity of the solution map for polynomials*, arXiv:2410.01326.
- A. Parusiński and A. Rainer, *Eigenvalue stability of Hermitian and normal matrices*, arXiv:2603.23056.

**Research Monograph.** *Perturbation of hyperbolic polynomials and related lifting problems*, enlarged and corrected version of the doctoral thesis as monograph, in preparation,

<http://www.mat.univie.ac.at/~armin/publ/roots-liffts.pdf>

**Habilitation Thesis.** *Perturbation theory for polynomials and linear operators & The convenient setting for Denjoy–Carleman differentiable mappings*,

<http://www.mat.univie.ac.at/~armin/publ/habilitation.pdf>

**Doctoral Thesis.** *Choosing roots of polynomials smoothly and lifting smooth curves over invariants*,

<http://www.mat.univie.ac.at/~armin/publ/dissertation.pdf>

**Diploma Thesis.** *Zerlegungsgleichheit von Kreis und Quadrat*, in German,

<http://www.mat.univie.ac.at/~armin/publ/diplom.pdf>