# Seminar: Ricci flow

### Winter term 2016/17

### Prof. Bernd Ammann

Friday 8:30-10:00,
Dates: 21.10., 28.10., 4.11., 11.11., 18.11., 25.11., 2.12., 9.12., 16.12., 23.12., 13.1., 20.1., 27.1., 3.2., 10.2., (15 weeks)

## 1 Arbitrary Dimensions, Part I

**Talk no. 1: Introduction.** *21.10.*
Definition of the Ricci flow, mention short time existence and uniqueness (proof later), first results and typical effects, scalar version of the maximum principle ([1, 4.1, Pages 93–94] for the max. princ.).

## 2 Ricci flow for surfaces

**Talk no. 2: Conformal changes and evolution of the curvature.** *28.10.* and *4.11.*

a) Conformal changes of metrics on surfaces [1, 5.1, Pages 106–109]
b) Evolution of the curvature [1, 5.2, Pages 109–111]

**Talk no. 3: Ricci solitons for surfaces.** *11.11.* and *18.11.*
[1, 5.3 and 5.4, Pages 111–119]

**Talk no. 4: Convergence for nonpositive Euler number.** *25.11.*

a) Convergence for negative Euler number [1, 5.5, Pages 120–123]
b) Convergence for vanishing Euler number [1, 5.6, Pages 123–128]

**Talk no. 5: Convergence for positive Euler number, Overview and Surface entropy.** *2.12.*

a) Overview [1, 5.7, Pages 128–132].
b) Surface entropy [1, 5.8, Pages 133–137]

**Talk no. 6: Upper bounds for $R$ and $\nabla R$.** *9.12.*
[1, 5.9, Pages 137–143]

**Talk no. 7: Harnack estimates.** *16.12.*
[1, 5.10, Pages 143–148]

**Talk no. 8: Convergence for positive curvature and estimates for the injectivity radius.** *23.12.*
Convergence for positive Gauß curvature [1, 5.11, Pages 148–149], behaviour of the injectivity radius [1, 5.12, Pages 149–153]

**Talk no. 9: Convergence for sign changing curvature and positive Euler number.** *13.1.*
[1, 5.13, Pages 153–156]

## Seminar-Homepage

`http://www.mathematik.uni-regensburg.de/ammann/lehre/2016w_ricci`
`http://www.mathematik.uni-regensburg.de/ammann/lehre/2016s_ricci2`

## Central Literature for dim=2


[1] B. Chow, D. Knopf; The Ricci Flow: An Introduction, AMS 2004, E-Book link UB Regensburg

[2] X. Chen, P. Lu, G. Tian; A note on uniformization of Riemann surfaces by Ricci flow, Proc. Amer. Math. Soc., **134**(2006) *3391–3393 (electronic)*, DOI 10.1090/S0002-9939-06-08360-2, `https://arxiv.org/abs/math/0505163`

[3] R. Hamilton; The Ricci flow on surfaces, contained in "Collected papers on Ricci flow", B. Ammann has a paper copy

[4] J.A. Isenberg, R. Mazzeo, N. Sesum; Ricci flow in two dimensions, `https://arxiv.org/abs/1103.4669`

[5] L. Ma; Ricci-Hamilton flow on surfaces, lecture notes, `http://faculty.math.tsinghua.edu.cn/~lma/lectures/ricciface2.pdf`

[6] B. Stetler; The Ricci flow on surfaces and the uniformization theorem, Master-Arbeit


## Central Literature for dim$\geq 2$


[7] M. Simon; A class of Riemannian manifolds that pinch when evolved by Ricci flow, Manuscripta Math. **101**, *89 – 114* (2000)

[8] S. Angenent, D. Knopf; An example of neckpinching for Ricci flow on $S^{n+1}$. Math. Res. Lett. **11**, 493–518 (2004). DOI

[9] S. Angenent, D. Knopf; Degenerate neckpinches in Ricci flow. J. Reine Angew. Math. **709**, *81–117* (2015).

## Extended Literature


[10] G. Besson; Preuve de la conjecture de Poincaré en déformant la métrique par la courbure de Ricci (d'après G. Perelman). Séminaire Bourbaki. Vol. 2004/2005. Astérisque No. 307 (2006), Exp. No. 947, ix, 309–347.

[11] C. Böhm; B. Wilking; Manifolds with positive curvature operators are space forms. Ann. of Math. (2) 167 (2008), no. 3, 1079–1097.

[12] M. Boileau, Geometrization of 3-manifolds with symmetries. Link siehe Homepage.

[13] S. Brendle; Ricci Flow and the Sphere Theorem, AMS Graduate Studies Vol. 111, 2010

[14] S. Brendle; R. Schoen; Manifolds with 1/4-pinched curvature are space forms. J. Amer. Math. Soc. 22 (2009), no. 1, 287–307.

[15] S. Brendle; R. Schoen; Classification of manifolds with weakly 1/4-pinched curvatures, Acta Math. 200, 1–13 (2008) See also ArXiv: `0705.3963`

[16] S. Brendle; R. Schoen; Curvature, sphere theorems, and the Ricci flow; to appear at Bull. AMS, ArXiv: `1001.2278`

[17] B. Chow; P. Lu; L. Ni; Hamilton's Ricci flow; Graduate Studies in Mathematics, 77; American Mathematical Society, Providence, RI; Science Press, New York, 2006

[18] H.D. Cao, B. Chow, S.C. Chu, S.T. Yau (editeurs), Collected Papers on Ricci Flow, International Press, Series in Geometry and Topology, Volume 37

[19] B. Chow, J. Diff. Geom., **33**, (1991), pp. 325–334

[20] B. Chow, S.-C. Chu, D. Glickenstein, C. Guenther, J. Isenberg, T. Ivey, D. Knopf, P. Lu, F. Luo, L. Ni, The Ricci flow, techniques and applications, PartI Geometric Aspects, AMS Math. surv. and Monographs, Vol. 135.

[21] DeTurck, D. M.; Deforming metrics in the direction of their Ricci tensors; J. Differential Geom. 18 (1983), no. 1, 157–162.

[22] A. Hatcher. Notes on basic 3-manifold topology, Link siehe Homepage.

[23] B. Kleiner, J. Lott, Notes on Perelman's Paper

[24] J. Lott, www-Seite, `http://math.berkeley.edu/~lott/ricciflow/perelman.html`

[25] J. Morgan, G. Tian, Ricci Flow and the Poincaré Conjecture, ArXiv: `math/0607607`

[26] J. Morgan, Recent progress on the Poincaré Conjecture and the classification of 3-manifolds. Bull. Amer. Math. Soc. 42 (2005), 57-78. Link siehe Homepage

[27] J. Milnor, Towards the Poincaré Conjecture and the Classification of 3-Manifolds, Notices Amer. Math. Soc. 50 (2003), no. 10, 1226–1233.

[28] G. Perelman, The entropy formula for the Ricci flow and its geometric applications, ArXiv: `math.DG/0211159`

[29] G. Perelman, Ricci flow with surgery on three-manifolds, ArXiv: `math.DG/0303109`

[30] G. Perelman, Finite extinction time for the solutions to the Ricci flow on certain three-manifolds, ArXiv: `math.DG/0307245`

[31] T. Shioya, T. Yamaguchi, Collapsing three-manifolds under a lower curvature bound. J. Differential Geom. 56 (2000), no. 1, 1–66.

[32] T. Shioya, T. Yamaguchi, Volume collapsed three-manifolds with a lower curvature bound, Math. Ann. 333 (2005), no. 1, 131–155.

[33] P. Topping; Lectures on the Ricci flow, LMS Lecture Note series 325, Cambridge

Alternative literature list on `web site of the seminar`.