

Mathematical General Relativity
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Geometry and Analysis

- [BM11] H. L. BRAY and W. P. MINICOZZI, II (eds.), *Surveys in geometric analysis and relativity*, Advanced Lectures in Mathematics **20**, International Press, Boston, 2011, ISBN 978-1-57146-230-5.
- [dC92] M. P. DO CARMO, *Riemannian geometry*, Birkhäuser, Boston, 1992, ISBN 0-8176-3490-8. MR 1138207. Zbl 0752.53001.
- [Eva10] L. C. EVANS, *Partial differential equations*, 2nd ed., Graduate Studies in Mathematics **19**, AMS, Providence, RI, 2010, ISBN 978-0-8218-4974-3. MR 2597943. Zbl 1194.35001.
- [GT01] D. GILBARG and N. S. TRUDINGER, *Elliptic partial differential equations of second order*, Springer, Berlin, 2001, ISBN 3-540-41160-7. MR 1814364. Zbl 1042.35002.
- [Jos96] J. JOST (ed.), *Geometric analysis and the calculus of variations*, International Press, Cambridge, MA, 1996, ISBN 1-57146-037-3. MR 1449400. Zbl 0914.00109.
- [Lee97] J. M. LEE, *Riemannian manifolds: An introduction to curvature*, Graduate Texts in Mathematics **176**, Springer, New York, 1997, ISBN 0-387-98271-X. MR 1468735. Zbl 0905.53001. doi:10.1007/b98852.
- [Lee03] J. M. LEE, *Introduction to smooth manifolds*, Graduate Texts in Mathematics **218**, Springer, New York, 2003, ISBN 0-387-95495-3. MR 1930091. Zbl 1030.53001.
- [O’N83] B. O’NEILL, *Semi-Riemannian geometry: with applications to relativity*, Pure and Applied Mathematics **103**, Academic Press, New York, 1983, ISBN 0-12-526740-1. MR 719023. Zbl 0531.53051.
- [Pet06] P. PETERSEN, *Riemannian geometry*, 2nd ed., Graduate Texts in Mathematics **171**, Springer, New York, 2006, ISBN 978-0387-29246-5; 0-387-29246-2. MR 2243772. Zbl 1220.53002. doi:10.1007/978-0-387-29403-2.
- [SY94] R. SCHOEN and S.-T. YAU, *Lectures on differential geometry*, Conference Proceedings and Lecture Notes in Geometry and Topology **1**, International Press, Cambridge, MA, 1994, ISBN 1-57146-012-8. MR 1333601. Zbl 0830.53001.

General Relativity

- [Cal00] J. J. CALLAHAN, *The geometry of spacetime: An introduction to special and general relativity*, Springer, New York, 2000, ISBN 0-387-98641-3. MR 1731438. Zbl 0937.83001.
- [Car04] S. CARROLL, *Spacetime and geometry: An introduction to general relativity*, Addison Wesley, San Francisco, 2004, ISBN 0-8053-8732-3. MR 2329798. Zbl 1131.83001.
- [HE73] S. W. HAWKING and G. F. R. ELLIS, *The large scale structure of space-time*, Cambridge Monographs on Mathematical Physics **1**, Cambridge University Press, London, 1973, ISBN 978-0-521-09906-6. MR 0424186. Zbl 0265.53054. Available at <http://www.cambridge.org/9780521099066>.
- [MTW73] C. W. MISNER, K. S. THORNE, and J. A. WHEELER, *Gravitation*, W. H. Freeman, San Francisco, 1973, ISBN 0716703440. MR 0418833.
- [Sch09] B. F. SCHUTZ, *A first course in general relativity*, 2nd ed., Cambridge University Press, Cambridge, 2009, ISBN 978-0-521-88705-2. Zbl 1173.53002. Available at <http://www.cambridge.org/9780521887052>.
- [Wal84] R. M. WALD, *General relativity*, University of Chicago Press, Chicago, 1984, ISBN 0-226-87032-4; 0-226-87033-2. MR 757180. Zbl 0549.53001.

Mathematical Relativity

- [CB09] Y. CHOQUET-BRUHAT, *General relativity and the Einstein equations*, Oxford University Press, Oxford, 2009, ISBN 978-0-19-923072-3. MR 2473363. Zbl 1157.83002.
- [Chr08] D. CHRISTODOULOU, *Mathematical problems of general relativity, I*, European Mathematical Society, Zürich, 2008, ISBN 978-3-03719-005-0. MR 2391586. Zbl 1136.83001. doi: 10.4171/005.
- [Chr09] D. CHRISTODOULOU, *The formation of black holes in general relativity*, European Mathematical Society, Zürich, 2009, ISBN 978-3-03719-068-5. MR 2488976. Zbl 1197.83004. doi: 10.4171/068.
- [CK93] D. CHRISTODOULOU and S. KLAINERMAN, *The global nonlinear stability of the Minkowski space*, Princeton Mathematical Series **41**, Princeton University Press, Princeton, NJ, 1993, ISBN 0-691-08777-6. MR 1316662. Zbl 0827.53055.
- [CD03] P. T. CHRUSCIEL and E. DELAY, *On mapping properties of the general relativistic constraints operator in weighted function spaces, with applications*, Mémoires de la Société Mathématique de France **94**, SMF, Paris, 2003. MR 2031583. Zbl 1058.83007. arXiv gr-qc/0301073.
- [CF04] P. T. CHRUSCIEL and H. FRIEDRICH (eds.), *The Einstein equations and the large scale behavior of gravitational fields: 50 years of the Cauchy problem in general relativity*, Birkhäuser, Basel, 2004, ISBN 3-7643-7130-7. MR 2098911. Zbl 1048.83001.
- [Ren08] A. D. RENDALL, *Partial differential equations in general relativity*, Oxford Graduate Texts in Mathematics **16**, Oxford University Press, Oxford, 2008, ISBN 978-0-19-921540-9; 978-0-19-921541-6. MR 2406669. Zbl 1148.35002.
- [Rin09] H. RINGSTRÖM, *The Cauchy problem in general relativity*, European Mathematical Society, Zürich, 2009, ISBN 978-3-03719-053-1. MR 2527641. Zbl 1169.83003. doi: 10.4171/053.

Survey Article

- [CGP10] P. T. CHRUSCIEL, G. J. GALLOWAY, and D. POLLACK, Mathematical general relativity: a sampler, *Bull. Amer. Math. Soc.* **47** (2010), no. 4, 567–638. MR 2721040. Zbl 1205.83002. doi: 10.1090/S0273-0979-2010-01304-5.

Positive Mass Theorem

- [Bar86] R. BARTNIK, The mass of an asymptotically flat manifold, *Comm. Pure Appl. Math.* **39** (1986), no. 5, 661–693. MR 849427. Zbl 0598.53045. doi: 10.1002/cpa.3160390505.
- [Lam11] M.-K. G. LAM, *The graph cases of the Riemannian positive mass and Penrose inequalities in all dimensions*, Thesis, Duke University, 2011, ISBN 978-1124-63054-0. MR 2873434. arXiv 1010.4256. Available at <http://proquest.umi.com/pqdlink?did=2357455081&Fmt=7&clientId=79356&RQT=309&VName=PQD>.
- [SY78] R. SCHOEN and S. T. YAU, Incompressible minimal surfaces, three-dimensional manifolds with nonnegative scalar curvature, and the positive mass conjecture in general relativity, *Proc. Nat. Acad. Sci. USA* **75** (1978), no. 6, 2567. MR 496776. Zbl 0385.53052. Available at <http://www.pnas.org/content/75/6/2567.abstract>.
- [SY79a] R. SCHOEN and S. T. YAU, On the proof of the positive mass conjecture in general relativity, *Comm. Math. Phys.* **65** (1979), no. 1, 45–76. MR 526976. Zbl 0405.53045. Available at <http://projecteuclid.org/getRecord?id=euclid.cmp/1103904790>.
- [SY79b] R. SCHOEN and S. T. YAU, Positivity of the total mass of a general space-time, *Phys. Rev. Lett.* **43** (1979), no. 20, 1457–1459. MR 547753. doi: 10.1103/PhysRevLett.43.1457.
- [SY81] R. SCHOEN and S. T. YAU, Proof of the positive mass theorem. II, *Comm. Math. Phys.* **79** (1981), no. 2, 231–260. MR 612249. Zbl 0494.53028. Available at <http://projecteuclid.org/getRecord?id=euclid.cmp/1103908964>.

Constraint Equations and the Initial-Value Formulation

- [Bar05] R. BARTNIK, Phase space for the Einstein equations, *Comm. Anal. Geom.* **13** (2005), no. 5, 845–885. MR 2216143. Zbl 1123.83006. Available at <http://intlpress.com/CAG/2005/13-5/CAG-13-5-845-885.pdf>.
- [CD03] P. T. CHRUSCIEL and E. DELAY, *On mapping properties of the general relativistic constraints operator in weighted function spaces, with applications*, Mémoires de la Société Mathématique de France **94**, SMF, Paris, 2003. MR 2031583. Zbl 1058.83007. arXiv gr-qc/0301073.
- [CS06] J. CORVINO and R. M. SCHOEN, On the asymptotics for the vacuum Einstein constraint equations, *J. Differential Geom.* **73** (2006), no. 2, 185–217. MR 2225517. Zbl 1122.58016. Available at <http://projecteuclid.org/getRecord?id=euclid.jdg/1146169910>.
- [FB52] Y. FOURÈS-BRUHAT, Théorème d'existence pour certains systèmes d'équations aux dérivées partielles non linéaires, *Acta Math.* **88** (1952), 141–225. MR 0053338. Zbl 0049.19201. doi: 10.1007/BF02392131.

Penrose Inequality

- [Bra01] H. L. BRAY, Proof of the Riemannian Penrose inequality using the positive mass theorem, *J. Differential Geom.* **59** (2001), no. 2, 177–267. MR 1908823. Zbl 1039.53034. Available at <http://projecteuclid.org/getRecord?id=euclid.jdg/1090349428>.
- [HI01] G. HUISKEN and T. ILMANEN, The inverse mean curvature flow and the Riemannian Penrose inequality, *J. Differential Geom.* **59** (2001), no. 3, 353–437. MR 1916951. Zbl 1055.53052. Available at <http://projecteuclid.org/getRecord?id=euclid.jdg/1090349447>.
- [Mar09] M. MARS, Present status of the Penrose inequality, *Classical Quantum Gravity* **26** (2009), no. 19, Article ID #193001. MR 2545137. Zbl 1178.83002. doi: 10.1088/0264-9381/26/19/193001.

Center of Mass

- [Hua09] L.-H. HUANG, On the center of mass of isolated systems with general asymptotics, *Classical Quantum Gravity* **26** (2009), no. 1, Article ID #015012. MR 2470255. Zbl 1157.83011. doi: 10.1088/0264-9381/26/1/015012.
- [Hua10] L.-H. HUANG, Foliations by stable spheres with constant mean curvature for isolated systems with general asymptotics, *Comm. Math. Phys.* **300** (2010), no. 2, 331–373. MR 2728728. Zbl 1206.53028. doi: 10.1007/s00220-010-1100-1.
- [HY96] G. HUISKEN and S.-T. YAU, Definition of center of mass for isolated physical systems and unique foliations by stable spheres with constant mean curvature, *Invent. Math.* **124** (1996), no. 1-3, 281–311. MR 1369419. Zbl 0858.53071. doi: 10.1007/s002220050054.

Scalar Curvature

- [BN04] H. L. BRAY and A. NEVES, Classification of prime 3-manifolds with Yamabe invariant greater than \mathbf{RP}^3 , *Ann. of Math. (2)* **159** (2004), no. 1, 407–424, [Corrigendum *ibid* 159, No. 2, p. 887 (2004)]. MR 2052359. Zbl 1066.53077. doi: 10.4007/annals.2004.159.407.
- [BMN11] S. BRENDLE, F. C. MARQUES, and A. NEVES, Deformations of the hemisphere that increase scalar curvature, *Invent. Math.* **185** (2011), no. 1, 175–197. MR 2810799. Zbl 1227.53048. doi: 10.1007/s00222-010-0305-4.
- [LP87] J. M. LEE and T. H. PARKER, The Yamabe problem, *Bull. Amer. Math. Soc. (N.S.)* **17** (1987), no. 1, 37–91. MR 888880. Zbl 0633.53062. doi: 10.1090/S0273-0979-1987-15514-5.