Rafe Mazzeo
Curriculum Vitæ

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Research Interests: Geometric and Microlocal Analysis, Partial Differential Equations.

Education:

B.S. Massachusetts Institute of Technology, 1982. Thesis under T. Shifrin: *Shrinking tubes and variants of the Gauss-Bonnet formula*

Ph.D. Massachusetts Institute of Technology, 1986. Thesis under R.B. Melrose: *Hodge cohomology of negatively curved manifolds*

Employment:

1986-1988 Stanford University, Szegö Assistant Professor.

1988-1992 Stanford University, Assistant Professor
(on leave, 1991-1993).

1991-1993 University of Washington, Assistant Professor.

1992-1997 Stanford University, Associate Professor.

1997-   Stanford University, Professor.

2007-2010 Department Chair

Awards and Fellowships:

National Science Foundation Postdoctoral Fellow, 1987-1990

Alfred P. Sloan Research Fellow, 1991-1995

National Science Foundation Young Investigator, 1992-1997

Louis and Claude Rosenberg Jr. University Fellow in Undergraduate Education, 2013-2018.

National Science Foundation DMS grants, 1990 – present.

Other Major Administrative Activities:

Faculty Director, Stanford Pre-Collegiate Studies/Stanford Online High School, 2010 –

Director, Institute for Advanced Study/Park City Mathematics Institute, September 2014 – August 2024.

Other:

Managing Editor, *Communications in Partial Differential Equations*, 1996 –

Editorial Board, AMS series *Graduate Studies in Mathematics*, 2010–2016.

Editorial Board, Notices of the American Mathematical Society, 2010 – 2013.

Editorial Board, Annales de l'IHP – equations nonlineaire, 2010 –.

Scientific Advisory Board, Banff International Research Station, 2008 – 2010.

Scientific Advisory Board, American Institute of Mathematics, 2010 –

Organizing Committee, MSRI Semester *Spectral Invariants*, Spring 2001.

Nachdiplom Lectures, ETH Zürich, Summer Semester 2004.

Yamabe Lectures, Northwestern University, April 2012.

Emil Grosswald Lectures, Temple University, October 2018.

Director, Stanford University Math Camp, 1995 –2010

Board of Directors, Mathematical Sciences Publishing, October 2014
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Publications:

1.   (with R. B. Melrose) "Meromorphic extension of the resolvent for spaces with asymptotically constant negative curvature", *Journal of Functional Analysis*, **75** (1987), pp. 260-310.

2.   "The Hodge cohomology of a conformally compact metric", *Journal of Differential Geometry*, **28** (1988), pp. 309-339.

3.   (with R. B. Melrose) "The adiabatic limit, Hodge cohomology, and Leray's spectral sequence for a fibration", *Journal of Differential Geometry*, **31** (1990), pp. 185-213.

4.   (with R. S. Phillips) "Hodge theory on hyperbolic manifolds", *Duke Mathematical Journal*, **60** No. 2, (1990), pp. 509-559.

5.   "Unique continuation at infinity and embedded eigenvalues for asymptotically hyperbolic manifolds", *American Journal of Mathematics*, **113** (1991), pp. 25-45.

6.   "Edge operators in geometry", *Proceedings – Analysis in Domains and on Manifolds with Singularities*, Breitenbrunn 1990. Teubner Texte zur Mathematik, Leipzig.

7.   (with N. Smale) "Conformally flat metrics of constant positive scalar curvature on subdomains of the sphere", *Journal of Differential Geometry*, **34** No. 3, (1991), pp. 581-621.

8.   "Elliptic theory of differential edge operators I. *Communications in Partial Differential Equations*, **16** No. 10, (1991), pp. 1616-1664.

9.   "Remarks on a paper of Friedlander concerning inequalities between Neumann and Dirichlet eigenvalues", *International Mathematics Research Notices* (in Duke Mathematics Journal), **4** (1991), pp. 41-48.

10.   "Regularity for the singular Yamabe problem", *Indiana University Mathematics Journal*, **40** (1991), pp. 1277-1299.

11.   (with R. B. Melrose) "Analytic surgery and the eta invariant", *Geometric and Functional Analysis*, **5** No. 1, (1995), pp. 14-75.

12.   (with N. Smale) "Perturbing away higher dimensional singularities from area minimizing hypersurfaces", *Communications in Analysis and Geometry*, **2** No. 2, (1994), pp. 313-336.

13.   (with D. Pollack and K. Uhlenbeck) "Moduli spaces of singular Yamabe metrics", *Journal of the American Mathematical Society*, **9** No. 2, (1996), pp. 303-344.

14.   (with A. Hassell and R.B. Melrose) "Analytic surgery and the accumulation of eigenvalues", *Communications in Analysis and Geometry*, **3** No. 1-2, (1995), pp. 115-222.

15.   (with R. Kusner and D. Pollack) "The moduli space of complete embedded constant mean curvature surfaces", *Geometric and Functional Analysis*, **6** No. 1, (1996), pp. 120-137.

16.   (with D. Burns) "On the geometry of cusps for $SU(n,1)$", in *Manifolds and Geometry*, Cambridge University Press (1996).

17.   (with F. Pacard) "A construction of singular solutions for a semilinear elliptic equation using asymptotic analysis", *Journal of Differential Geometry*, **44** No. 2, (1996), pp. 331-370.

18.   Review of "Heat Kernels and Dirac Operators" by N. Berline, E. Getzler and M. Vergne. *Bulletin (New Series) of the American Mathematical Society*, **33** No. 1 (1996), pp. 125-129.

19.   (with A. Hassell and R.B. Melrose) "A signature formula for manifolds with corners of codimension 2", *Topology*, **36** No. 5 (1997), pp. 1055-1075.

20.   (with D. Pollack and K. Uhlenbeck) "Connected sum constructions for constant scalar curvature metrics", *Topological Methods in Nonlinear Analysis*, **6** No. 2. (1995), pp. 207-233.

21.   (with D. Pollack) "Gluing and moduli for noncompact geometric problems" in *Geometric theory of singular phenomena in partial differential equations, Symposia Mathematica Vol. XXXII*, Cambridge Univ. Press (1998), pp. 17-51.

22.   (with F. Pacard) "Constant scalar curvature metrics with isolated singularities", *Duke Mathematical Journal* **99** No. 3 (1999), pp. 353-418.

23.   (with N. Korevaar, F. Pacard and R. Schoen) "Refined asymptotics for constant scalar curvature metrics with isolated singularities", *Inventiones Mathematicæ*, **135** (1999), pp. 233-272.

24.   (with F. Pacard) "Constant mean curvature surfaces with Delaunay ends", *Communications in Analysis and Geometry*, **9** No. 1 (2001), pp. 169-237.

25.   (with P. Piazza) "Dirac operators, heat kernels and microlocal analysis Part II: Analytic surgery", *Rendicondi di Matematica e delle sue applicazioni* **18** (1998), pp. 221-288.

26. (with R.B. Melrose) "Pseudodifferential operators on manifolds with fibred boundary", *Asian Journal of Mathematics* **2** No. 4 (1999) pp. 833 - 866.

27. (with F. Pacard and D. Pollack) "Connected sums of constant mean curvature surfaces in Euclidean 3-space", *Journal für die Reine und Angewandte Mathematik*, **536** (2001), 115-165.

28. (with R. McOwen) "Singular Sturm-Liouville theory on manifolds", *Journal of Differential Equations*, **176** No. 2 (2001), pp. 387-444.

29. "Kähler-Einstein metrics singular along a smooth divisor", *Journées Équations aux Dérivées Partielles, Saint-Jean-de-Monts*, (1999).

30. (with A. Vasy) "Resolvents, Martin boundaries and Riemannian products". *Geometric and Functional Analysis* **12** (2002), pp. 1018-1079.

31. (with M. Taylor) "Curvature and uniformization", *Israel Journal of Mathematics* **130** (2002), 323-346.

32. (with F. Pacard) "Poincaré-Einstein metrics and the Schouten tensor". *Pacific Journal of Mathematics*, **212** No. 1 (2003), 169-185.

33. (with J. Isenberg and D. Pollack) "Gluing and wormholes for the Einstein constraint equations". *Communications in Mathematical Physics* **231** (2002), pp. 529-568.

34. "Spectral invariants", in *The Emissary* (Mathematical Sciences Research Institute newsletter), Fall 2001.

35. (with F. Pacard and D. Pollack) "Conformal theory of Alexandrov embedded constant mean curvature surfaces in $\mathbf{R}^3$" in *Global Theory of Minimal Surfaces*, AMS/Clay Mathematics Proceedings **2**, Ed. David Hoffman. (2005).

36. (with F. Pacard) "Bifurcating nodoids" in *Topology and Geometry: Commemorating SISTAG, Contemporary Mathematics*, American Mathematical Society **314** (2002), pp. 169-186.

37. (with J. Isenberg and D. Pollack) "Topology of vacuum spacetimes". *Annales Henri Poincaré* **4** No. 2 (2003), pp. 369 - 383.

38. (with T. Hausel and E. Hunsicker) "L^2 cohomology of gravitational instantons", *Duke Mathematical Journal*, **122** No. 3 (2004), 485-548.

39. (with A. Vasy) "Scattering theory on SL(3)/SO(3): connections with quantum 3-body scattering", *Proceedings of the London Mathematical Society* **94** No. 3 (2007), 545–593.

40.   (with A. Vasy) "Analytic continuation of the resolvent on SL(3)/SO(3)", *American Journal of Mathematics* **126** (2004), 821-844.

41.   "Recent advances in the global theory of constant mean curvature surfaces." in *Noncompact problems at the intersection of geometry, analysis and topology*, Contemporary Mathematics Vol. 350, American Mathematical Society.

42.   (with P. Chrusciel) "On "many black hole" vacuum spacetimes", *Classical and Quantum Gravity* **20** (2003), pp. 1-26.

43.   (with F. Pacard) "Maskit combinations of Poincaré-Einstein metrics" *Advances in Mathematics* **204** No. 2 (2006), 379–412.

44.   (with A. Vasy) "Analytic continuation of the resolvent of the Laplacian on symmetric spaces of noncompact type" *Journal of Functional Analysis* **228** No. 2 (2005), pp. 311-368.

45.   (with F. Pacard) "Foliations by constant mean curvature tubes" *Communications in Analysis and Geometry* **13** No. 4 (2005), pp. 633-670.

46.   "Pseudodifferential analysis for the resolvent on noncompact symmetric spaces" in *Partial differential equations and inverse problems*, Contemporary Mathematics **362**, American Mathematical Society (2004), 289-301.

47.   (with F. Mahmoudi and F. Pacard) "Constant mean curvature hypersurfaces condensing along a submanifold" *Geometric and Functional Analysis* **16** No. 4 (2006), 924–958.

48.   (with E. Hunsicker) "Harmonic forms on manifolds with edges" *International Mathematics Research Notices* **52** (2005), pp. 3229-3272.

49.   (with E. Leichtnam and P. Piazza) "The index of Dirac operators on manifolds with fibered boundaries", *Bulletin of the Belgian Mathematical Society – Simon Stevin* **13** No. 5 (2006), 845–855.

50.   (with O. Biquard) "Parabolic geometries as conformal infinities of Einstein metrics". *Archivum Mathematicum* (Brno) **42** (2006), supplement, pp. 85–104.

51.   Review of "Nonlinear elliptic equations in conformal geometry" by S.Y. Alice Chang. *Bulletin (New Series) of the American Mathematical Society*, **44** (2007), pp. 323-330.

52.   "Resolution blowups, spectral convergence and quasi-asymptotically conical spaces". Journées Équations aux Dérivées Partielles, (2006), Exposé VIII, 16 pages.

53. (with O. Biquard) "A nonlinear Poisson transform for Einstein metrics on product spaces." *Journal of the European Mathematical Society* **13** no. 5 (2011), pp. 1423-1475.

54. (with M. Saez) "Self-similar expanding solutions for the planar network flow" in *Analytic aspects of problems in Riemannian geometry: Elliptic PDEs, solitons and computer imaging* Eds. Paul Baird, Ahmad El Soufi, Ali Fardoun, Rachid Regbaoui, *Seminaires et Congres, Societe des Mathematiques de France* **19** (2009), pp. 159–173.

55. (with M. Singer) "Some remarks on conic degeneration and bending of Poincaré-Einstein metrics", preprint, September 2007, 9 pages.

56. (with F. Pacard) "Constant curvature foliations on asymptotically hyperbolic spaces", *Revista Matemática Iberoamericana* **27** No. 1 (2011), pp. 303–333.

57. (with O. Kaven and D. Pollard) "Constraining surface interpolations using elastic plate bending solutions with applications to geologic folding", *Mathematical Geosciences* **41** No. 1 (2009) 1-14.

58. (with L. Ji and N. Sesum) "Ricci flow on surfaces with cusps", *Mathematische Annalen* **345** No. 4 (2009), pp. 819 - 834.

59. (with Lei Zhu, Louis Lee, Yunzhi Ma, Yinyu Ye and Lei Xing) "Using total-variation regularization for segment-based dose optimization with specific numbers of segments", *Physics in Medicine and Biology* **53**, (2008) 6653-6672.

60. (with S. Alexakis) "Renormalized area and properly embedded minimal surfaces in hyperbolic 3-manifolds". *Communications in Mathematical Physics* **297** No. 3 (2010), pp. 621–651.

61. (with I. Birindelli) "Symmetry for solutions of two-phase semilinear elliptic equations on hyperbolic space", *Indiana University Mathematical Journal* **58** (2009), pp. 2347-2368.

62. "Flexibility of singular Einstein metrics", Asterisque **321**, Geometrie Differentielle, Physique Mathematique, Mathematique et Société (I), Volume en l'honneur de Jean Pierre Bourguignon (O. Hijazi, éditeur) (2008), pp. 169-193.

63. (with A. Butscher) "CMC hypersurfaces condensing to geodesic segments and rays in Riemannian manifolds", *Annali della Scuola Normale Superiore di Pisa, Classe di Scienze* (5) Vol. XI (2012), pp. 1-54.

64. (with J. Rowlett) "A heat trace anomaly on polygons", *Mathematical Proceedings of the Cambridge Philosophical Society* **159** no. 2 (2015), pp. 303-319.

65. (with P. Albin, E. Leichtnam and P. Piazza) "The signature package on Witt spaces", *Annales Scientifiques de l'Ecole Normale Superieure* **45** no. 2 (2012), pp. 241-310.

66. (with C. Epstein) "Wright-Fisher diffusion in one dimension", *SIAM Journal on Mathematical Analysis* **42** No. 2, (2010), pp. 568 - 608.

67. (with G. Montcouquiol) "Infinitesimal rigidity of cone-manifolds and the Stoker problem for hyperbolic and Euclidean polyhedra", *Journal of Differential Geometry* **87** No. 3, (2011), pp. 525-576.

68. (with M. del Mar González and Y. Sire) "Singular solutions of fractional order conformal Laplacians", *Journal of Geometric Analysis* **22** no. 3 (2012), pp. 845-863.

69. (with C. Guillarmou) "Spectral analysis of the Laplacian on geometrically finite hyperbolic manifolds", *Inventiones Mathematicae* **187** no. 1 (2012), pp. 99-144.

70. (with J. Isenberg and N. Sesum) "Ricci flow on asymptotically conical surfaces with nontrivial topology", *Journal für die Reine und Angewandte Mathematik* **676** (2013), pp. 227-248.

71.   (with J. Isenberg and N. Sesum) "Ricci flow on open surfaces" in *Surveys in Geometric Analysis and Relativity*, Advanced Lectures in Mathematics 20. Eds. H.L. Bray, W.P. Minicozzi, Higher Education Press, Beijing (2011), pp. 259-280.

72. (with W. Arendt) "Friedlander's eigenvalue inequalities and the Dirichlet-to-Neumann semigroup", *Communications on Pure and Applied Analysis*, **11** (2012) No. 6, pp. 2201-2212.

73.   (with B. Vertman) "Analytic torsion on manifolds with edges", *Advances in Mathematics* **231** no. 2 (2012), pp. 1000-1040.

74. (with T. Jeffres and Y. Rubinstein) "Kähler-Einstein metrics with edge singularities" (with an Appendix by C. Li and Y. Rubinstein). *Annals of Mathematics* **183** no. 1 (2016), pp. 95-176.

75. (with C.L. Epstein) "Degenerate diffusion operators arising in population biology". Princeton Annals of Mathematical Studies Vol. 185 Princeton University Press, Princeton NJ (2013).

76.   (with M. Saez-Trumper) "Multiple layer solutions of the Allen-Cahn equation in $\mathbf{H}^n$". *Proceedings of the American Mathematical Society* **142** No. 8 (2014), pp. 2859-2869.

77.   (with P. Chrusciel) "Solutions of the vacuum Einstein constraint equations on manifolds with cylindrical ends, I: the Lichnerowicz equation". *Annales Henri Poincaré* **16** No. 5 (2015), pp. 815–840.

78.   (with P. Chrusciel and S. Pocchiola) "Initial data sets with ends of cylindrical type: II, the vector constraint equation". *Advances in Theoretical and Mathematical Physics* **17** No. 4 (2013), pp. 829–865.

79.   (with S. Alexakis) "The Willmore functional on complete minimal surfaces in $\mathbf{H}^3$: boundary regularity and bubbling". *Journal of Differential Geometry* **101** no. 3 (2015), pp. 369–422.

80. (with C.L. Epstein) "Analysis of degenerate diffusion operators arising in population biology" in *From Fourier analysis and number theory to Radon transforms and geometry*, pp. 203-216. Developments in Mathematics **28**, Springer, New York (2013).

81.   (with Y. Rubinstein) "The Ricci continuity method for the complex Monge-Ampére equation, with applications to Kähler-Einstein edge metrics". *Comptes Rendus Academie Sciences Paris, Series I*, **350** (2012), pp. 693–697.

82.   (with L. Ji, W. Müller and A. Vasy) "Spectral theory for the Weil-Petersson Laplacian on the Riemann moduli space". *Commentarii Mathematicæ Helveticii* **89** No. 4 (2014), pp. 867–894.

83. (with F. Martin and M. Rodriguez) "Minimal surfaces with finite total curvature and arbitrary topology in $\mathbf{H}^2 \times \mathbf{R}$". *Geometry and Topology* **18** No. 1 (2014), pp. 141-178.

84.   (with D. Baskin) "Some global aspects of linear wave equations", in *Evolution Equations*, pp. 73-95. Clay Mathematical Proceedings, Volume 17 (2013), Eds. D. Ellwood, I. Rodnianski, G. Staffilani, J. Wunsch.

85. (with K. Akutagawa and G. Carron) "The Yamabe problem on stratified spaces", *Geometric and Functional Analysis* **24** No. 4 (2014), pp. 1039-1079.

86. (with C.L. Epstein) "The geometric microlocal analysis of generalized Kimura and Heston diffusions" in *Analysis and topology in nonlinear differential equations*, pp. 241-266. Progess in Nonlinear Differential Equations and Applications **85**, Birkhäuser-Springer, Cham (2014).

87. (with K. Akutagawa and G. Carron) "The Yamabe problem on Dirichlet spaces". Preprint, May 2013. 25 pages. To appear, *Surveys of the Yau Mathematical Science Center.*

88. (with Y. Rubinstein and N. Sesum) "Ricci flow on spaces with conic singularities", *Analysis and Partial Differential Equations* **8** no. 4 (2015), pp. 839-882.

89. (with B. Vertman) "Elliptic theory of differential edge operators, II: boundary value problems". *Indiana University Mathematics Journal* **63** No. 6 (2014), pp. 1911–1955.

90. (with E. Bahuaud and E. Woolgar) "Renormalized volume and the evolution of APEs". *Geometric Flows*, **1** no. 1 (2015), pp. 126-138.

91. (with P. Albin, E. Leichtnam and P. Piazza) "Hodge theory on Cheeger spaces". Preprint, July 2013. 60 pages. To appear in *Journal für die Reine und Angewandte Mathematik.*

92. (with P. Albin, E. Leichtnam and P. Piazza) "The Novikov conjecture on Cheeger spaces". *Journal of Non-Commutative Geometry* **11** (2017) no. 2, pp. 451–506.

93. (with P. Albin, M. Banagl, E. Leichtnam and P. Piazza) "Refined intersection homology on non-Witt spaces". *Journal of Topology and Analysis* **7** No. 1 (2015), pp. 105–133.

94. (with E. Witten) "The Nahm pole boundary condition" in *The Influence of Solomon Lefschetz in Geometry and Topology: 50 Years of Mathematics at CINVESTAV'*, Contemporary Mathematics **621**, pp. 171-226. American Mathematical Society, Providence.

95. (with J. Dilts, J. Isenberg and C. Meier) "Non-CMC solutions of the Einstein constraint equations on asymptotically Euclidean manifolds" *Classical and Quantum Gravity* **17** (2014), pp. 1-10.

96. (with A. Pelayo and T. Ratiu) "L^2 cohomology and complete Hamiltonian manifolds". *Journal of Geometry and Physics* **87** (2015), pp. 305–313.

97. (with J. Swoboda, H. Weiss and F. Witt) "Ends of the moduli space of Higgs bundles". *Duke Mathematical Journal* **165** No. 12 (2016), pp. 2227-2271.

98. (with C.L. Epstein) "Harnack inequalities and heat kernel estimates for degenerate diffusion operators arising in population biology". *Applied Mathematics Research eXpress* **2** (2016), pp. 217-280. doi:10.1093/amrx/abw002

99. (with A. Degeratu) "Fredholm theory for elliptic operators on quasi-asymptotically conical spaces". *Proceedings of the London Mathematics Society (3)*, **116** (2018), No. 5, pp. 1112-1160.

100. (with R. Conlon and F. Rochon) "The moduli space of asymptotically cylindrical Calabi-Yau manifolds". *Communications in Mathematical Physics* **338** (2015) 953–1009.

101. (with K. Akutagawa and G. Carron) "Hölder regularity of solutions for Schrödinger operators on stratified spaces". *Journal of Functional Analysis* **269** No. 3 (2015) 815–840.

102. (with J. Swoboda, H. Weiss and F. Witt) "Limiting configurations for solutions of Hitchin's equations". *Séminaire de Théorie Spectrale et Géométrie (Grenoble)* **31** (2012-2014), pp. 91-116.

103. (with F. Pacard and T. Zolotareva) "Higher codimension isoperimetric problems". *Annali della Scuola Normale Superiore di Pisa, Classe di Scienze'* (5) **17** No. 3 (2017), pp. 819–851.

104. (with J. Swoboda) "Asymptotics of the Weil-Petersson metric". *International Mathematics Research Notices* **IMRN 2017** No. 6, pp. 1749-1786.

105. (with B. Kloeckner) "On the asymptotic behavior of minimal surfaces in $\mathbf{H}^2 \times \mathbf{R}$". *Indiana University Journal of Mathematics* **66** (2017) no. 2, pp. 631–658.

106. (with Hartmut Weiss) "The Teichmüller theory of conic surfaces". Preprint, September 2015. 48 pages. in *Geometry, Analysis and Probability (in Honor of Jean-Michel Bismut*, Eds. Bost, Hofer, Labourie, Le Jan, Ma, Zhang, Progress in Mathematics No. 310, Birkhäuser (2017), pp. 127–164.

107. "Sharp parabolic regularity and geometric flows on singular spaces" , *Journ'ees 'equations aux d'eriv'ees partielles* (2015) Exp. 6, 11 pages.

108. (with Olivia Dimutrescu, Laura Fredrickson, Georgios Kydonakis, Motohico Mulase, Andy Neitzke) "Opers versus Nonabelian Hodge", July 2016, arXiv:1607.02172, 23 pages. To appear, *Journal of Differential Geometry*

109. (with Eric Bahuaud and Eric Woolgar) "Ricci flow and volume renormalizability". July 2016, arXiv:1607.08558 19 pages.

110. (with Leonor Ferrer, Francisco Martin and Magdalena Rodriguez) "Properly embedded minimal annuli in $\mathbf{H}^2 \times \mathbf{R}$", April 2017, arXiv:1704.07788. 48 pages. Submitted to *Mathematische Annalen*

111. (with Jan Swoboda, Hartmut Weiss and Frederik Witt) "Asymptotic geometry of the Hitchin moduli space". To appear, *Communications in Mathematical Physics*

112. (with Xuwen Zhu) "Conical metrics on Riemann surfaces, I: the compactified configuration space and regularity". October 2017. arXiv:1710.09781. 61 pages. Submitted to *Geometry and Topology*

113. (with Siqi He) "The extended Bogomolny equations". October 2017. arXiv:1710.10645. 30 pages. Submitted to *Geometry and Topology*

114.   (with Mike Holst and David Maxwell) "Conformal Fields and the Structure of the Space of Solutions of the Einstein Constraint Equations". November 2017. arXiv:1711.01042. 30 pages. Submitted to *Advances in Theoretical and Mathematical Physics*

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