

SHOCK WAVES IN GAS DYNAMICS

Abdolrahman Razani

Abstract. Shock wave theory was studied in literature by many authors. This article presents a survey with references about various topics related to shock waves: Hyperbolic conservation laws, Well-posedness theory, Compactness theory, Shock and reaction-diffusion wave, The CJ and ZND theory, Existence of detonation in Majda's model, Premixed laminar flame, Multidimensional gas flows, Multidimensional Riemann problem.

[Full text](#)

Acknowledgement. This paper owes much to the references [23], [44], [68], [61], [62], [82], [107], [125] and [137]. The author acknowledges a great debt to them.

References

- [1] J.D. Avrin, *Qualitative theory for a model of laminar flames with arbitrary nonnegative initial data*, J. Differential Equations **84** (1990), 290-308. [MR1047571\(91h:35316\)](#). [Zbl 0712.35047](#).
- [2] J.D. Avrin, *Qualitative theory of the Cauchy problem for a one-step reaction model on bounded domains*, SIAM J. Math. Anal. **22** (1991) 379-391. [MR1084962\(92h:35103\)](#). [Zbl 0737.35030](#).
- [3] J.D. Avrin, *Flame propagation in models of complex chemistry*, Houston J. Math. **26** (2000), 145-163. [MR1814732\(2001j:80004\)](#). [Zbl 0979.35073](#).
- [4] S. Benzoni-Gavage, D. Serre, *Compacite par compensation pour une classe de systemes hyperboliques de p lois de conservation ($p \geq 3$)*, Rev. Mat. Iberoam. **10** (1994), 557-579. [MR1308703\(96b:35136\)](#). [Zbl 0834.35081](#).

2000 Mathematics Subject Classification:35L67, 76L05, 35L65, 35L05.

Keywords: shock wave, conservation law.

This paper was prepared while the author was visiting the Royal Institute of Technology (KTH), Stockholm, in the period of his sabbatical leave. It would be a pleasure to thank Imam Khomeini International University for its financial support and KTH for its hospitality.

<http://www.utgjiu.ro/math/sma>

- [5] S. Benzoni-Gavage, D. Serre, K. Zumbrun, *Alternate Evans functions and viscous shock waves*, SIAM J. Math. Anal. **32** (2001), 929-962. [MR1828312\(2002b:35144\)](#). [Zbl 0985.34075](#).
- [6] H. Berestycki, B. Nicolaenko, B. Scheurer, *Sur quelques problèmes asymptotiques avec applications à la combustion*, C. R. Acad. Sci. Paris Sér. I Math. **296** (1983), 105-108. [MR0691376\(84c:34078\)](#). [Zbl 0526.34044](#).
- [7] H. Berestycki, B. Nicolaenko, B. Scheurer, *Travelling wave solutions to combustion models and their singular limits*, SIAM J. Math. Anal. **16** (1985), 1207-1242. [MR0807905\(87h:35326\)](#). [Zbl 0596.76096](#).
- [8] J. Billingham, G. N. Mercer, *The effect of heat loss on the propagation of strongly exothermic combustion waves*, Combust. Theory Model. **5** (2001), 319-342. [MR1860153\(2002g:80007\)](#). [Zbl 1023.76054](#).
- [9] A. Bressan, *A locally contractive metric for systems of conservation laws*, Ann. Scuola Norm. Sup. Pisa Cl. Sci. **22** (1995), 109-135. [MR1315352\(96k:35113\)](#). [Zbl 0867.35060](#).
- [10] A. Bressan, G. Crasta, B. Piccoli, *Well posedness of the Cauchy problem for $n \times n$ systems of conservation laws*, Mem. Amer. Math. Soc. **146** (2000), no. 694. [MR1686652\(2000m:35122\)](#). [Zbl 0958.35001](#).
- [11] A. Bressan, P. Lefloch, *Uniqueness of weak solutions to systems of conservation laws*, Arch. Rational Mech. Anal. **140** (1997), 301-317. [MR1489317\(98m:35125\)](#). [Zbl 0903.35039](#).
- [12] J. Buckmaster, G.S.S. Ludford, *Theory of laminar flames*, Cambridge Monographs on Mechanics and Applied Mathematics. Electronic & Electrical Engineering Research Studies: Pattern Recognition & Image Processing Series, 2. Cambridge University Press, Cambridge-New York, 1982. [MR0666866\(84f:80011\)](#). [Zbl 0557.76001](#).
- [13] T. Chang, L. Hsiao, *Riemann problem and discontinuous initial value problem for typical quasilinear hyperbolic system without convexity*, Acta. Math. Sin. **20** (1977), 229-331.
- [14] S. Chen, *Non-symmetric conical supersonic flow*, in: *Hyperbolic Problems: Theory, Numerics, and Applications*, 1 (Zurich 1998), Internat. Ser. Numer. Math. **129**, Birkhäuser, Basel, 1999, 149-158. [MR1715743\(2000f:76059\)](#). [Zbl 0926.35118](#).
- [15] G.Q. Chen, H. Frid, *Large-time behavior of entropy solutions of conservation laws*, J. Differential Equations **152** (1999), 308-357. [MR1674529\(99m:35150\)](#). [Zbl 0926.35085](#).

Surveys in Mathematics and its Applications **2** (2007), 59 – 89

<http://www.utgjiu.ro/math/sma>

- [16] K.N. Chuey, C.C. Conley, J.A. Smoller, *Positively invariant regions for systems of nonlinear diffusion equations*, Indiana Univ. Math. J. **26** (1997), 373-392. [MR0430536\(55#3541\)](#). [Zbl 0368.35040](#).
- [17] P. Clavin, *Dynamical behavior of premixed fronts in laminar and turbulent flows*, Prog. Energy Comb. Sci. **11** (1985), 1-59.
- [18] P. Colella, A. Majda, V. Roytburd, *Theoretical and numerical structure for reacting shock waves*, SIAM J. Sci. Stat. Comput. **7** (1986), 1059-1080. [MR0857783\(87i:76037\)](#). [Zbl 0633.76060](#).
- [19] R. Courant, K.O. Friedrichs, *Supersonic flows and shock waves*, Applied Mathematical Sciences **21**, Springer-Verlag, New York-Heidelberg, 1976. [MR0421279\(54#9284\)](#).
- [20] E. Conway, J.A. Smoller, *Global solutions of the Cauchy problem for quasi-linear first order equations in several space variable*, Commun. Pure Appl. Math. **19** (1966), 95-105. [MR0192161\(33#388\)](#). [Zbl 0138.34701](#).
- [21] C.M. Dafermos, *The entropy rate admissibility criterion for solutions of hyperbolic conservation laws*, J. Diff. Eqns. **14** (1973), 202-212. [MR0328368\(48#6710\)](#). [Zbl 0262.35038](#).
- [22] C.M. Dafermos, *Solution of the Riemann problem for a class of hyperbolic systems of conservation laws by the viscosity method*, Arch. Rational Mech. Anal. **52** (1973), 1-9. [MR0340837\(49#5587\)](#). [Zbl 0262.35034](#).
- [23] C.M. Dafermos, *Hyperbolic conservation laws in continuum physics. 2nd ed.*, Grundlehren der mathematischen Wissenschaften **325**, Springer-Verlag, Berlin, 2005. [MR2169977\(2006d:35159\)](#). [Zbl 1078.35001](#).
- [24] C.M. Dafermos, X. Geng, *Generalized characteristic, uniqueness and regularity of solutions in a hyperbolic system of conservation laws*, Proc. Roy. Soc. Edinb., Sect. A **116** (1990), 245-278. [MR1127926\(92h:35135\)](#). [Zbl 0776.35033](#).
- [25] C.M. Dafermos, L. Hsiao, *Hyperbolic systems and balance laws with inhomogeneity and dissipation*, Indiana Univ. Math. J. **31** (1982), 471-491. [MR0662914\(83m:35093\)](#). [Zbl 0497.35058](#).
- [26] X. Ding, G.Q. Chen, P. Luo, *Convergence of the fractional step Lax-Friedirichs scheme and Godunov scheme for the isentropic system of gas dynamics*, Commun. Math. Phys. **121** (1989), 63-84. [MR0985615\(90d:65168\)](#). [Zbl 0689.76022](#).
- [27] R.J. Diperna, *Decay and asymptotic behavior of solutions to nonlinear hyperbolic systems of conservation laws*, Indiana Univ. Math. J. **24** (1974/75), 1047-1071. [MR0410110\(53#13860\)](#). [Zbl 0309.35050](#).

Surveys in Mathematics and its Applications **2** (2007), 59 – 89

<http://www.utgjiu.ro/math/sma>

- [28] R.J. Diperna, *Singularises of solutions of nonlinear hyperbolic system of conservation laws*, Arch. Rational Mech. Anal. **60** (1975/76), 75-100. [MR0393867\(52#14675\)](#).
- [29] R.J. Diperna, *Convergence of approximate solutions to conservation laws*, Arch. Rational Mech. Anal. **82** (1983), 27-70. [MR0684413\(84k:35091\)](#). [Zbl 0519.35054](#).
- [30] R.J. Diperna, *Convergence of the viscosity method for isentropic gas dynamics*, Commun. Math. Phys. **91** (1983), 1-30. [MR0719807\(85i:35118\)](#). [Zbl 0533.76071](#).
- [31] W. Doring, *The detonation process in gases*, Ann. Physik **43** (1943), 421.
- [32] W. Fickett, *Detonation in miniature*, Amer. J. Phys. **47** (1979), 1050-1059.
- [33] W. Fickett, W. Davis, *Detonation*, University of California Press, Berkeley, Los Angeles, 1979.
- [34] C. Fries, *Nonlinear asymptotic stability of general small-amplitude viscous laxian shock waves*, J. Diff. Eqns. **146** (1998), 185-202. [MR1625739\(99h:35132\)](#). [Zbl 0921.35106](#).
- [35] R.A. Gardner, *On the Detonation of Combustible Gas*, Trans. Amer. Math. Soc. **277** (1983), 431-468. [MR0694370\(84g:35118\)](#). [Zbl 0543.76152](#).
- [36] R.A. Gardner, K. Zumbrun, *The gap lemma and geometric criteria for instability of viscous shock profiles*, Commun. Pure Appl. Math. **51** (1998), 797-855. [MR1617251\(99c:35152\)](#). [Zbl 0933.35136](#).
- [37] I. Gasser, P. Szmolyan, *A geometric singular perturbation analysis of detonation and deflagration waves*, SIAM J. Math. Anal. **24** (1993), 968-986. [MR1226859\(94h:35206\)](#). [Zbl 0783.76099](#).
- [38] I. Gasser, P. Szmolyan, *Detonation and Deflagration Waves with Multistep Reaction Schemes*, SIAM J. Appl. Math. **55** (1995), 175-191. [MR1313012\(95i:35229\)](#). [Zbl 0814.34028](#).
- [39] D. Gilbarg, *The existence and limit behavior of the one-dimensional shock layer*, Amer. J. Math. **73** (1951), 256-275. [MR0044315\(13,401e\)](#). [Zbl 0044.21504](#).
- [40] H. Gilquin, J. Laurens, C. Rosier, *Multi-dimensional Riemann problems for linear hyperbolic systems*, RAIRO Modél. Math. Anal. Numér **30** (1996), 527-548. [MR1411390\(97k:35155\)](#). [Zbl 0865.35078](#).

Surveys in Mathematics and its Applications **2** (2007), 59 – 89

<http://www.utgjiu.ro/math/sma>

- [41] J. Glimm, *Solutions in the large for nonlinear hyperbolic systems of equations*, Comm. Pure Appl. Math. **18** (1965), 697-715. [MR0194770\(33#2976\)](#). [Zbl 0141.28902](#).
- [42] J. Glimm, P.D. Lax, *Decay of solutions of systems of hyperbolic conservation laws*, Bull. Amer. Math. Soc. **73** (1967), 105. [MR0204826\(34#4662\)](#). [Zbl 0146.33803](#).
- [43] J. Goodman, *Nonlinear asymptotic stability of viscous shock profiles for conservation laws*, Arch. Rational Mech. Anal. **95** (1986), 110-146. [MR0853782\(88b:35127\)](#). [Zbl 0631.35058](#).
- [44] B. Hanouzet, R. Natalini, A. Tesei, *On the Chapman-Jouguet limit for a combustion model*, SIAM J. Math. Anal. **29** (1998), 619-636. [MR1617759\(99b:76046\)](#). [Zbl 0928.35092](#).
- [45] A. Heibig, *Existence and uniqueness of solutions for some hyperbolic systems of conservation laws*, Arch. Rational Mech. Anal. **126** (1994), 79-101. [MR1268050\(95d:35101\)](#). [Zbl 0810.35058](#).
- [46] M. Hesaaraki, A. Razani, *Detonative Travelling Waves for Combustions*, Applicable Anal. **77** (2001), 405-418. [MR1975745\(2004b:76153\)](#). [Zbl 1022.80007](#).
- [47] M. Hesaaraki, A. Razani, *On the existence of Chapman-Jouguet detonation waves*, Bull. Austral. Math. Soc. **63** (2001), 485-496. [MR1834949\(2002h:35189\)](#). [Zbl 0986.34008](#).
- [48] E. Jouguet, *Sur la propagation des discontinuités dans les fluides*, C. R. Acad. Sci., Paris, Sér. I **132** (1901), 673-676.
- [49] A.K. Kapila, B.J. Mathowsky, A. Van Harten, *An asymptotic theory of deflagration and detonations 1. The steady solutions*, SIAM J. Appl. Math. **43** (1983), 491-519. [MR0700527\(85b:80012\)](#).
- [50] D.X. Kong, T. Yang, *A note on: "Well-posedness theory for hyperbolic conservation laws"* [Comm. Pure Appl. Math. **52** (1999), no. 12, 1553-1586; [MR1711037\(2000m:35126\)](#)] by T.P. Liu, Yang., Appl. Math. Letters **16** (2003), 143-146. [MR1963080\(2004c:35269\)](#). [Zbl 1073.35159](#).
- [51] G. Kreiss, H.O. Kreiss, *Stability of systems of viscous conservation laws*, Commun. Pure Appl. Math. **23** (1998), 1397-1424. [MR1639151\(2000c:35156\)](#). [Zbl 0935.35013](#).
- [52] S.N. Kruzhkov, *First order quasilinear equations in several independent variables*, Math. USSR Sb. **81** (1970), 217-243. [Zbl 0215.16203](#).

Surveys in Mathematics and its Applications **2** (2007), 59 – 89

<http://www.utgjiu.ro/math/sma>

- [53] B. Larrouturou, *The equations of one-dimensional unsteady flame propagation: existence and uniqueness*, SIAM J. Math. Anal. **19** (1988), 32-59. [MR0924543\(89i:80002\)](#). [Zbl 0662.35090](#).
- [54] P.D. Lax, *The multiplicity of eigenvalues*, Bull. Amer. Math. Soc. (N.S.) **2** (1982), 213-214. [MR0640948\(83a:15009\)](#). [Zbl 0483.15006](#).
- [55] P.D. Lax, *Hyperbolic System of Conservation Laws and the Mathematical Theory of Shock Waves*, Conference Board of the mathematical Science Regional Conference Series in Applied Mathematics **11**, Society for Industrial and Applied Mathematics, Philadelphia, Pa., 1973. [MR0350216\(50#2709\)](#). [Zbl 0268.35062](#).
- [56] P.D. Lax, *Hyperbolic System of Conservation Laws II*, Commun. Pure Appl. Math. **10** (1957), 537-566. [MR0093653\(20#176\)](#).
- [57] P.D. Lax, *Shock waves and entropy*, Contrib. nonlinear functional Analysis, Proc. Sympos. Univ. Wisconsin, Madison 1971 (1971), 603-634. [Zbl 0268.35014](#).
- [58] P.D. Lax, C.D. Levermore, S. Venakidis, *The generation and propagation of oscillations in dispersive initial value problems and their limiting behavior*, in: *Important Developments in Solution Theory*, Springer Ser. Nonlinear Dynam. Springer, Berlin, 1993, 205-241. [MR1280476\(95c:35245\)](#). [Zbl 0819.35122](#).
- [59] R.J. Leveque, B. Temple, *Convergence of Godunov's method for a class of 2×2 systems of conservation laws*, Trans. Amer. Math. Soc. **288** (1985), 115-123. [MR0773050\(87c:35105\)](#). [Zbl 0561.65067](#).
- [60] T. Li, *On the initiation problem for a combustion model*, J. Differential Equations **112** (1994), 351-373. [MR1293475\(95g:35112\)](#). [Zbl 0808.35073](#).
- [61] T. Li, W. Sheng, *The general multi-dimensional Riemann problem for hyperbolic systems with real constant coefficients*, Discrete Contin. Dynam. Systems **8** (2002), 737-744. [MR1897878\(2002m:35137\)](#). [Zbl 1005.35061](#).
- [62] T. Li, W. Sheng, *The general Riemann problem for the linearized system of two-dimensional isentropic flow in gas dynamics*, J. Math. Anal. Appl. **276** (2002), 598-610. [MR1944778\(2003j:76087\)](#). [Zbl 1106.76437](#).
- [63] J. Li, T. Zhang, S. Yang, *The Two-Dimensional Riemann Problem in Gas Dynamics*, Pitman Monograph and Surveys in Pure and Applied Mathematics, Longman, Harlow **98**, 1998. [MR1697999\(2000d:76106\)](#). [Zbl 0935.76002](#).
- [64] W. Lien, T.P. Liu, *Nonlinear stability of a self-similar 3-dimensional gas flow*, Comm. Math. Phys. **204** (1999), 525-549. [MR1707631\(2000f:76106\)](#). [Zbl 0945.76033](#).

Surveys in Mathematics and its Applications **2** (2007), 59 – 89

<http://www.utgjiu.ro/math/sma>

- [65] P.L. Lions, *Mathematical topics in fluid mechanics. Vol. 1. Incompressible models*. Oxford Lecture Series in Mathematics and its Applications **3** Oxford Science Publications. The Clarendon Press, Oxford University Press, New York, 1996. [MR1422251](#)(98b:76001). [Zbl 0866.76002](#).
- [66] P.L. Lions, *Mathematical topics in fluid mechanics. Vol. 2. Compressible models*. Oxford Lecture Series in Mathematics and its Applications **10** Oxford Science Publications. The Clarendon Press, Oxford University Press, New York, 1998. [MR1637634](#)(99m:76001). [Zbl 0908.76004](#).
- [67] P.L. Lions, B. Perthame, E. Tadmor, *A kinetic formulation of multidimensional scalar conservation laws and related equations*, J. Amer. Math. Soc. **7** (1994), 169-192. [MR1201239](#)(94d:35100). [Zbl 0820.35094](#).
- [68] T.P. Liu, *On shock wave theory*, Taiwanese J. Math. **4** (2000), 9-20. [MR1757979](#)(2001c:35151). [Zbl 0960.35062](#).
- [69] T.P. Liu, *Zero dissipation and stability of shocks*, Methods Appl. Anal. **5** (1998), 81-94. [MR1631343](#)(99m:35155). [Zbl 0912.35107](#).
- [70] T.P. Liu, *Pointwise convergence to N-waves for solutions of hyperbolic conservation laws*, Bull. Inst. Math. Acad. Sinica **15** (1987), 1-17. [MR0947772](#)(89h:35202). [Zbl 0646.35053](#).
- [71] T.P. Liu, *Linear and nonlinear large-time behavior of solutions of general systems of hyperbolic conservation laws*, Comm. Pure Appl. Math. **30** (1977), 767-796. [MR0499781](#)(58#17556). [Zbl 0358.35014](#).
- [72] T.P. Liu, *The deterministic version of the Glimm scheme*, Comm. Math. Phys. **57** (1977), 135-148. [MR0470508](#)(57#10259). [Zbl 0376.35042](#).
- [73] T.P. Liu, *Admissible solutions of hyperbolic conservation laws*, Mem. Amer. Math. Soc. **30** (1981), no.240. [MR0603391](#)(82i:35116). [Zbl 0446.76058](#).
- [74] T.P. Liu, *Interactions of nonlinear hyperbolic waves*, Proceedings of the 1989 conference on nonlinear analysis, Academia Sinica, Taipei, Republic of China, 19-24 June, 1989. Singapore: World Scientific.(1991), 171-183. [MR1103571](#)(92a:35111). [Zbl 0820.35109](#).
- [75] T.P. Liu, *Pointwise convergence to shock waves for viscous conservation laws*, Comm. Pure Appl. Math. **50** (1997), 1113-1182. [MR1470318](#)(98j:35121). [Zbl 0902.35069](#).
- [76] T.P. Liu, *The entropy condition and the admissibility of Shocks*, J. Math. Anal. Appl. **53** (1976), 78-88. [MR0387830](#)(52#8669). [Zbl 0332.76051](#).

Surveys in Mathematics and its Applications **2** (2007), 59 – 89

<http://www.utgjiu.ro/math/sma>

- [77] T.P. Liu, *Nonlinear stability of shock waves for Viscous Conservation Laws*, *Memoirs. Amer. Math. Soc.* **328** (1985). [MR0791863\(87a:35127\)](#). [Zbl 0617.35058](#).
- [78] T.P. Liu, Z. Xin, *Pointwise decay to contact discontinuities for systems of viscous conservation laws*, *Asian J. Math.* **1** (1997), 34-84. [MR1480990\(99b:35138\)](#). [Zbl 0928.35095](#).
- [79] T.P. Liu, T. Yang, *A new entropy functional for a scalar conservation law*, *Comm. Pure Appl. Math.* **52** (1999), 1427-1442. [MR1702712\(2000e:35139\)](#). [Zbl 0941.35051](#).
- [80] T.P. Liu, T. Yang, *Well-posedness theory for system of conservation laws*, *Comm. Pure Appl. Math.* **52** (1999), 1553-1586. [MR1702712\(2000e:35139\)](#). [Zbl 0931.35097](#).
- [81] T.P. Liu, L. A. Ying, *Nonlinear stability of strong detonations for a viscous combustion model*, *SIAM J. Math. Anal.* **26** (1995), 519-528. [MR1325901\(95k:35101\)](#). [Zbl 0829.35053](#).
- [82] T.P. Liu, S.H. Yu, *Hyperbolic conservation laws and dynamic systems*, *Discrete. Contin. Dynam. Syst.* **6** (2000), 143-145. [MR1739597\(2000j:35179\)](#). [Zbl 1021.35067](#).
- [83] T.P. Liu, S.H. Yu, *Nonlinear stability of weak detonation waves for a combustion model*, *Comm. Math. Phys.* **204** (1999), 551-586. [MR1707627\(2000g:76108\)](#). [Zbl 0976.76036](#).
- [84] T.P. Liu, S.H. Yu, *Riemann problem for viscous conservation laws*, To appear.
- [85] G. Lyng, K. Zumbrun, *A stability index for detonation waves in Majda's model for reacting flow*, *Physica D* **194** (2004), 1-29. [MR2075662\(2005d:35134\)](#). [Zbl 1061.35018](#).
- [86] A. Majda, *A qualitative model for dynamic combustion*, *SIAM J. Appl. Math.* **41** (1981), 70-93. [MR0622874\(82j:35096\)](#). [Zbl 0472.76075](#).
- [87] A. Majda, *High Mach number combustion*, *Lecture in Appl. Math.* **24**, Amer. Math. Soc., Providence, 1986. [MR0840071\(87c:80022\)](#).
- [88] A. Majda, *Compressible Fluid Flow and Systems of Conservation Laws in Several Space Variable*, Springer, New York, 1984. [MR0748308\(85e:35077\)](#). [Zbl 0537.76001](#)
- [89] A. Majda, R. Pego, *Stable viscosity matrices for systems of conservation laws*, *J. Diff. Eqns.* **56** (1985), 229-262. [MR0774165\(86b:35132\)](#). [Zbl 0512.76067](#).

Surveys in Mathematics and its Applications **2** (2007), 59 – 89

<http://www.utgjiu.ro/math/sma>

- [90] M. Marion, *Qualitative properties of a nonlinear system for laminar flames without ignition temperature*, Nonlinear Anal. **9** (1985), 1269-1292. [MR0813658\(87j:80016\)](#). [Zbl 0648.76051](#).
- [91] G.N. Mercer, R.O. Weber, H.S. Sidhu, *An oscillatory route to extinction for solid fuel combustion waves due to heat losses*, Proc. R. Soc. A **454** (1998), 2015-2022. [MR1640072\(99d:80011\)](#). [Zbl 0926.65087](#).
- [92] J. Von Neumann, *Theory of Detonation Waves*, Progress REPORT 238, Office of Scientific Research and Development, Report **549** (1942); Ballistic Research Lab. File X₁₂₂.
- [93] J. Von Neumann, *Theory of shock waves*, Division, N.D.R.C., (1943) Office of Scientific Research and Development, Report 1140.
- [94] J. Von Neumann, *Collected works. Vol. VI: Theory of games, astrophysics, hydrodynamics and meteorology*, General editor: A. H. Taub. A Pergamon Press Book The Macmillan Co., New York 1963, 178-218. [MR0157876\(28#1105\)](#). [Zbl 0188.00105](#).
- [95] O.A. Olejnik, *Uniqueness and stability of the generalized solution of the Cauchy problem for a quasi-linear equation*, Usp. Mat. Nauk **14** (1959), 165-170. [MR0117408\(22#8187\)](#). [Zbl 0132.33303](#).
- [96] Y. Oshime, *Canonical forms of 3×3 strictly hyperbolic systems with real constant coefficients*, J. Math. Kyoto. Univ. **31-4** (1991), 937-982. [MR1141079\(93f:35135\)](#). [Zbl 0797.35107](#).
- [97] Y. Oshime, *On the canonical forms of 3×3 non-diagonalizable hyperbolic systems with real constant coefficients*, J. Math. Kyoto. Univ. **31-4** (1991), 983-1021. [MR1141080\(93f:35136\)](#). [Zbl 0793.35057](#).
- [98] A. Razani, *Chapman-Jouguet Detonation for a Qualitative Model*, Bull. Austral. Math. Soc. **66** (2002), 393-403. [MR1939202\(2003i:35162\)](#). [Zbl 1029.34023](#).
- [99] A. Razani, *Weak and Strong Detonation Profiles for a Qualitative Model*, J. Math. Anal. Appl. **276** (2002), 868-881. [MR1944793\(2003i:76061\)](#). [Zbl 1106.76400](#).
- [100] A. Razani, *The structure of shock waves for a viscous combustion model*, Submitted.
- [101] A. Razani, *Existence of Chapman-Jouguet Detonation for a Viscous Combustion Model*, J. Math. Anal. Appl. **293** (2004), 551-563. [MR2053898\(2005a:80009\)](#). [Zbl 1058.35165](#).

Surveys in Mathematics and its Applications **2** (2007), 59 – 89

<http://www.utgjiu.ro/math/sma>

- [102] A. Razani, *On the existence of premixed laminar flames*, Bull. Austral. Math. Soc. **69** (2004), 415-427. [MR2066659](#)(2005k:80010). [Zbl 1058.34057](#).
- [103] B. Riemann, *Über die Fortpflanzung ebener Luftwellen von endlicher Schwingungsweite*, Gött. Abh. Math. Cl. **8** (1860), 43-65.
- [104] J.M. Roquejoffre, D. Terman, *The asymptotic stability of a traveling wave solution arising from a combustion model*, Nonlinear Anal. **22** (1994), 137-154. [MR1258953](#)(95a:35074). [Zbl 0802.35071](#).
- [105] J.M. Roquejoffre, J.P. Vila, *Stability of ZND detonation waves in the Majda combustion model*, Asymptot. Anal. **18** (1998), 329-348. [MR1668958](#)(99m:80016). [Zbl 0931.35026](#).
- [106] R. Rosales, A. Majda, *Weakly nonlinear detonation waves*, SIAM J. Appl. Math. **43** (1983), 1086-1118. [MR0718631](#)(86a:80003). [Zbl 0572.76062](#).
- [107] D. Serre, *Systems of Conservation Laws: A Challenge for the XXIst Century*, Mathematics unlimited 2001 and beyond, 1061-1080, Springer, Berlin, 2001. [MR1852203](#). [Zbl 1005.35002](#).
- [108] D. Serre, *Semi-linear and kinetic relaxation for systems of conservation laws. (Relaxation semi-lineaire et cinétique de lois de conservation)*, Ann. Inst. Henri Poincaré, Anal. Non Linéaire **17** (2000), 169-192. [MR1753092](#)(2001g:35159). [Zbl 0963.35117](#).
- [109] D. Serre, *Discrete shock profiles and their stability. (English summary) Hyperbolic Problems: Theory, Numerics and Applications, Vol. II* (Zurich 1998), Internat. Ser. Numer. Math. **130**, Birkhäuser, Basel, (1999), 843-853. [MR1717256](#)(2000k:35190). [Zbl 0928.35102](#).
- [110] D. Serre, *Systems of conservation laws. 2. Geometric structures, oscillations, and initial-boundary value problems*. Translated from the 1996 French original by I. N. Sneddon. Cambridge University Press, Cambridge, 2000. [MR1775057](#)(2001c:35146). [Zbl 0936.35001](#).
- [111] J. Shearer, *Global existence and compactness in L^p for the quasi-linear wave equation*, Commun. Partial Diff. Eqns. **19** (1994), 1829-1877. [MR1301175](#)(95m:35120). [Zbl 0855.35078](#).
- [112] M. Short, J.W. Dold, *Weak detonations, their paths and transition to strong detonation*, Combust. Theory Modelling **6** (2002), 279-296. [MR1915330](#)(2003g:76070). [Zbl 1068.76527](#).
- [113] M. Short, J.J. Quirk, *On the nonlinear stability and detonability limit of a detonation wave for a model three-step chain-branching reaction*, J. Fluid Mech. **339** (1979), 89-119. [MR1453722](#)(98c:80008). [Zbl 0903.76038](#).

Surveys in Mathematics and its Applications **2** (2007), 59 – 89

<http://www.utgjiu.ro/math/sma>

- [114] G.I. Sivashinsky, *Instabilities, pattern formation, and turbulence in flames*, Annu. Rev. Fluid Mech. **15** (1983), 179-199. [Zbl 0538.76053](#).
- [115] J.A. Smoller, *Shock waves and reaction-diffusion equations*, Second edition. Grundlehren der Mathematischen Wissenschaften [Fundamental Principles of Mathematical Sciences], 258. Springer-Verlag, New York, 1994. [MR1301779\(95g:35002\)](#). [Zbl 0807.35002](#).
- [116] G. Strang, *On strong hyperbolicity*, J. Math. Kyoto. Univ. **6** (1967), 397-417. [MR0217439\(36#529\)](#). [Zbl 0174.15103](#).
- [117] A. Szepessy, *Dynamics and stability of a weak detonation wave*, Comm. Math. Phys. **202** (1999), 547-569. [MR1690953\(2000g:35086\)](#). [Zbl 0947.35019](#).
- [118] A. Szepessy, Z. Xin, *Nonlinear stability of viscous shock waves*, Arch. Rational Mech. Anal. **122** (1993), 53-103. [MR1207241\(93m:35125\)](#). [Zbl 0803.35097](#).
- [119] L. Tartar, *Compensated compactness and applications to partial differential equations*, Nonlinear analysis and mechanics: Heriot-Watt Symp., Vol. 4, Edinburgh 1979, Res. Notes Math. **39** (1979), 136-210. [MR0584398\(81m:35014\)](#). [Zbl 0437.35004](#).
- [120] R. Temam, *Navier-Stokes equations. Theory and numerical analysis*, Studies in Mathematics and its Applications, Vol. 2. North-Holland Publishing Co., Amsterdam-New York-Oxford, 1977. [MR0609732\(58#29439\)](#). [Zbl 0568.35002](#).
- [121] B. Temple, *System of conservation laws with invariant submanifolds*, Tran. Amer. Math. Soc. **280** (1983), 781-795. [MR0716850\(84m:35080\)](#).
- [122] D. Terman, *Connection problems arising from nonlinear diffusion equations*, Nonlinear diffusion equations and their equilibrium states, II (Berkeley, CA, 1986), 315-332, Math. Sci. Res. Inst. Publ., 13, Springer, New York, 1988. [MR0956096\(90c:35125\)](#). [Zbl 0685.35056](#).
- [123] A.E. Tzavaras, *Materials with internal variables and relaxation to conservation laws*, Arch. Rational Mech. Anal. **146** (1999), 129-155. [MR1718478\(2000i:74004\)](#). [Zbl 0973.74005](#).
- [124] A.I. Vol'pert, *Spaces BV and quasilinear equations*, Math. USSR Sb., (Russian) Mat. Sb. (N.S.) **73** (115) (1967), 255-302. [MR0216338\(35#7172\)](#). [Zbl 0168.07402](#).
- [125] D.H. Wagner, *The existence and behavior of viscous structure for plan detonation waves*, SIAM J. Math. Anal. **20** (1989) 1035-1054. [MR1009344\(90h:80009\)](#). [Zbl 0675.76069](#).

Surveys in Mathematics and its Applications **2** (2007), 59 – 89

<http://www.utgjiu.ro/math/sma>

- [126] D.H. Wagner, *Existence of deflagration waves: Connection to a degenerate critical point*, Proceeding of the conference on Physical Mathematics and Nonlinear Partial Differential Equations, (J. H. Lightbourne and S. M. Rankin, Eds.), West Virginia University, Marcel-Dekker, New York, 1985. [MR0826834\(87i:80013\)](#). [Zbl 0586.35068](#).
- [127] D.H. Wagner, *Premixed laminar flames as travelling waves*, Lectures in Appl. Math. **24** (1986), 229-237. [MR0840083\(87e:80018\)](#).
- [128] D.H. Wagner, *Detonation Waves and Deflagration Waves in the One Dimensional ZND Model for High Mach Number Combustion*, Contemporary Maths **100** (1989), 277-285. [MR1033523](#). [Zbl 0682.76046](#).
- [129] D.H. Wagner, *Equivalence of the Euler and Lagrangian equations of gas dynamics for weak solutions*, J. Differential Equations **68** (1987), 118-136. [MR0885816\(88i:35100\)](#). [Zbl 0647.76049](#).
- [130] R.O. Weber, G.N. Mercer, H.S. Sidhu, B.F. Gray, *Combustion waves for gases ($le = 1$) and solids ($le \rightarrow \infty$)*, Proc. R. Soc. A **453** (1997), 1105-1118. [MR1449095\(98a:80007\)](#). [Zbl 0885.76105](#).
- [131] F.A. Williams, *Combustion Theory*, The Benjamin/Cummings Publ. Co, Menlo Park, 1985.
- [132] L. Ying, T. Yang, C. Zhu, *The rate of asymptotic convergence of strong detonations for a model problem*, Japan J. Indust. Appl. Math. **16** (1999), 467-487. [MR1719218\(2000i:80009\)](#). [Zbl 0647.76049](#).
- [133] L. Ying, C. Wang, *The discontinuous initial value problem of a reacting gas flow system*, Trans. Amer. Math. Soc. **266** (1981), 361-387. [MR0617539\(82k:35076\)](#). [Zbl 0482.76071](#).
- [134] S.H. Yu, *Zero-dissipation limit of solutions with shocks for systems of hyperbolic conservation laws*, Arch. Rational Mech. Anal. **146** (1999), 275-370. [MR1718368\(2001b:35213\)](#). [Zbl 0935.35101](#).
- [135] Y.B. Zeldovich, *On theory of the propagation of detonations in gaseous systems*, Tech. Memos. Nat. Adv. Comm. Aeronaut. (1950), no. 1261, 50 pp. [MR0038203\(12,370b\)](#).
- [136] Y.B. Zeldovich, A.S. Kompaneets, *Theory of Detonation*, Academic Press, New York, 1960.
- [137] Y.B. Zeldovich, Y.P. Raizer, *Elements of gasdynamics and the classical theory of shock waves*, Academic Press, INC, 1968.

Surveys in Mathematics and its Applications **2** (2007), 59 – 89

<http://www.utgjiu.ro/math/sma>

- [138] T. Zhang, Y. Zheng, *Axisymmetric solutions of the Euler equations for polytropic gases*, Arch. Rational Mech. Anal. **142** (1998), 253–279. [MR1636533\(2000d:76103\)](#). [Zbl 0909.76087](#).
- [139] K. Zumbrun, P. Howard, *Pointwise semigroup methods and stability of viscous shock waves*, Indiana Univ. Math. J. **47** (1998), 741–871. [MR1665788\(99m:35157\)](#). [Zbl 0928.35018](#).
- [140] K. Zumbrun, P. Howard, *Errata to: "Pointwise semigroup methods, and stability of viscous shock waves"* [Indiana Univ. Math. J. **47** (1998), 741–871], Indiana Univ. Math. J. **51** (2002), 1017–1021. [MR1947866\(2004a:35155\)](#).
- [141] K. Zumbrun, D. Serre, *Viscous and inviscid stability of multidimensional planar shock fronts*, Indiana Univ. Math. J. **48** (1999), 937–992. [MR1736972\(2001h:35122\)](#). [Zbl 0944.76027](#).

Abdolrahman Razani
Department of Mathematics, Faculty of Science,
Imam Khomeini International University,
Postal code: 34149-16818,
Qazvin, Iran.
e-mail: razani@ikiu.ac.ir
<http://math.ipm.ac.ir/razani>
