Li, Fucai; **Zhang, Shuxing**; **Zhang, Zhipeng**

Low Mach number limit of the compressible Euler-Cattaneo-Maxwell equations. (English)

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Summary: We study the low Mach number limit of the compressible Euler-Cattaneo-Maxwell (ECM) equations with small variations of density, temperature and heat flux. For well-prepared initial data, we prove that, in the framework of classical solutions, the solution of the compressible ECM equations converges to that of the incompressible Euler-Maxwell equations as the Mach number tends to zero. We also obtain the convergence rate and establish the local existence of classical solution to the limit equations. Furthermore, we discuss briefly the low Mach limits of the isentropic Euler-Maxwell equations, the non-isentropic Euler-Maxwell equations without heat conduction, the Euler-Maxwell equations with linear Cattaneo's heat transfer law and the Euler-Fourier-Maxwell equations. We find that they share the same limit equations, i.e., the incompressible Euler-Maxwell equations. This confirms a physical fact that for the well-prepared initial data and considering small variations of density, temperature and heat flux, the various types of non-isentropic Euler-Maxwell equations have the similar incompressibility as the isentropic equations.

MSC:

76X05 Ionized gas flow in electromagnetic fields; plasmic flow
35L45 Initial value problems for first-order hyperbolic systems
35B40 Asymptotic behavior of solutions to PDEs

Keywords:

compressible Euler-Cattaneo-Maxwell equations; low Mach number limit; incompressible Euler-Maxwell equations

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References:

[1] Alsunaidi, MA; Imtiaz, SS; El-Ghazaly, SM, Electromagnetic wave effects on microwave transistors using a full-wave time-domain model, IEEE Trans. Microwave Theory Tech., 44, 799-808 (1996)· doi:10.1109/22.506437

[2] Chen, FF, Introduction to Plasma Physics and Controlled Fusion (1984), New York: Plenum Press, New York· doi:10.1007/978-1-4757-5595-4

[3] Chen, G-Q; Jerome, J.; Wang, D., Compressible Euler-Maxwell equations, Transp. Theory Stat. Phys., 29, 311-331 (2000) · Zbl 1019.82023 · doi:10.1080/00411450008205877

[4] Dinklage, A.; Klinger, T.; Marx, G.; Schweikhard, L., Plasma Physics. Lecture Notes in Physics (2005), Berlin: Springer, Berlin · Zbl 1083.76002

[5] Duan, R.; Liu, Q.; Zhu, C., The Cauchy problem on the compressible two-fluids Euler-Maxwell equations, SIAM J. Math. Anal., 44, 102-133 (2012) · Zbl 1236.35116 · doi:10.1137/110838406

[6] Feireisl, E.; Novotný, A., Singular Limits in Thermodynamics of Viscous Fluids (2009), Basel: Birkhäuser, Basel · Zbl 1176.35126 · doi:10.1007/978-3-7643-8843-0

[7] Germain, P.; Masmoudi, N., Global existence for the Euler-Maxwell system, Ann. Sci. Éc. Norm. Supér., 47, 469-503 (2014) · Zbl 1311.35195 · doi:10.24033/asens.2219

[8] Jerome, JW, The Cauchy problem for compressible hydrodynamic-Maxwell systems: a local theory for smooth solutions, Differ. Integral Equ., 16, 1345-1368 (2003) · Zbl 1074.76062

[9] Jiang, S.; Ju, Q.; Li, F., Low Mach number limit for the multi-dimensional full magnetohydrodynamic equations, Nonlinearity, 25, 1351-1365 (2012) · Zbl 1376.76077 · doi:10.1088/0951-7715/25/5/1351

[10] Jiang, S.; Ju, Q.; Li, F.; Xin, Z., Low Mach number limit for the full magnetohydrodynamic equations with general initial data, Adv. Math., 259, 384-420 (2014) · Zbl 1334.35216 · doi:10.1016/j.aim.2014.03.022

[11] Kawashima, S.; Ueda, Y., Mathematical entropy and Euler-Cattaneo-Maxwell system, Anal. Appl., 14, 101-143 (2016) · Zbl 1336.35226 · doi:10.1142/S0219530515400035

[12] Klainerman, S.; Majda, AJ, Singular limits of quasilinear hyperbolic systems with large parameters and the incompressible limit of compressible fluids, Comm. Pure Appl. Math., 34, 481-524 (1981) · Zbl 0476.76068 · doi:10.1002/cpa.3160340405

[13] Lions, P-L; Masmoudi, N., Incompressible limit for a viscous compressible fluid, J. Math. Pures Appl., 77, 585-627 (1998) · Zbl 0909.35101 · doi:10.1016/S0021-7824(98)80139-6

[14] Majda, AJ, Compressible Fluid Flow and Systems of Conservation Laws in Several Space variables (1984), New York: Springer-Verlag, New York· doi:10.1007/978-1-4612-1116-7

[15] Majda, AJ; Bertozzi, AL, Vorticity and Incompressible Flow (2001), Cambridge: Cambridge Univ. Press, Cambridge · Zbl 0983.76001 · doi:10.1017/CBO9780511613203

[16] Markowich, PA; Ringhofer, CA; Schmeiser, C., Semiconductor Equations (1990), Vienna: Springer-Verlag, Vienna· doi:10.1007/978-3-7091-6961-2

[17] Métivier, G.; Schochet, S., The incompressible limit of the non-isentropic Euler equations, Arch. Ration. Mech. Anal., 158, 61-90 (2001) · Zbl 0974.76072 · doi:10.1007/PL00004241

[18] Peng, Y-J, Stability of non-constant equilibrium solutions for Euler-Maxwell equations, J. Math. Pures Appl., 103, 39-67 (2015) · Zbl 1304.35104 · doi:10.1016/j.matpur.2014.03.007

[19] Peng, Y-J; Wang, S., Convergence of compressible Euler-Maxwell equations to compressible Euler-Poisson equations, Chin. Ann. Math. Ser. B, 5, 89-108 (2007) · Zbl 1145.35347

[20] Peng, Y-J; Wang, S., Rigorous derivation of incompressible e-MHD equations from compressible Euler-Maxwell equations, SIAM J. Math. Anal., 40, 540-565 (2008) · Zbl 1170.35081 · doi:10.1137/070686056

[21] Peng, Y-J; Wang, S., Convergence of compressible Euler-Maxwell equations to incompressible Euler equations, Comm. Partial Differential Equations, 33, 349-376 (2008) · Zbl 1145.35054 · doi:10.1080/03605300701318989

[22] Peng, Y-J; Wang, S.; Gu, Q., Relaxation limit and global existence of smooth solutions of compressible Euler-Maxwell equations, SIAM J. Math. Anal., 43, 944-970 (2011) · Zbl 1231.35039 · doi:10.1137/100786927

[23] Schochet, S., The compressible Euler equations in a bounded domain: existence of solutions and the incompressible limit, Comm. Math. Phys., 104, 49-75 (1986) · Zbl 0612.76082 · doi:10.1007/BF01210792

[24] Tan, Z.; Wang, Y.; Wang, Y., Decay estimates of solutions to the compressible Euler-Maxwell system in \({\mathbb{R}}^3\), J. Differ. Equ., 257, 2846-2873 (2014) · Zbl 1296.83018 · doi:10.1016/j.jde.2014.05.056

[25] Ueda, Y.; Wang, S.; Kawashima, S., Dissipative structure of the regularity type and time asymptotic decay of solutions for the Euler-Maxwell system, SIAM J. Math. Anal., 44, 2002-2017 (2012) · Zbl 1252.35073 · doi:10.1137/100806515

[26] Volpert, AI; Hudjaev, SI, On the Cauchy problem for composite systems of nonlinear differential equations, Mat. Sb., 87, 504-528 (1972)

[27] Yang, J.; Wang, S., Convergence of the nonisentropic Euler-Maxwell equations to compressible Euler-Poisson equations, J. Math. Phys., 50, 397-400 (2009) · Zbl 1373.35260

[28] Yong,W.-A.: Basic aspects of hyperbolic relaxation systems, in: H. Freistühler, A. Szepessy (Eds.), Advances in the Theory of Shock Waves, in: Progr. Nonlinear Differential Equations Appl., Vol. 47, Birkhäuser, Boston, (2001), pp. 259-305 · Zbl 1017.35068

[29] Yong, W-A, Singular perturbations of first-order hyperbolic systems with Stiff source terms, J. Differ. Equ., 155, 89-132 (1999) · Zbl 0942.35110 · doi:10.1006/jdeq.1998.3584

[30] Zhang, S., Low Mach number limit for the full compressible Navier-Stokes equations with Cattaneo's heat transfer law, Nonlinear Anal., 184, 83-94 (2019) · Zbl 1482.35182 · doi:10.1016/j.na.2019.02.005