CONCLUSIONS

The main results obtained are:

1. Simulation of convective detonation waves in a porous medium was carried out.

   A new model was proposed based on the lattice gas method. This model allows one to take into account the stochastic nature of this phenomenon. Propagation of the wave front and its curved shape were obtained automatically in computations in contrast with existing continual models. Computed wave velocity and pressure profile were in good agreement with experimental ones.

2. Based on the numerical investigation of the component mixing process, a possible mechanism was explained of the time and grain size dependence of electric conductivity in detonation products of heterogeneous HEs.

   Flow development for different initial geometry was considered. Time dependencies of detonation product conductivity of heterogeneous HEs were obtained. The dependencies obtained are in qualitative agreement with the experimental results.

3. The modification of the LBE method was developed for simulation of electrohydrodynamic flows. Several methods to compute the convective charge transport were considered. Theoretical values of the numerical diffusivity were compared with the computation results.

   Development of EHD-flow in different geometry was studied. In two-dimensional case, the flow has oscillatory character caused by the charge injection in discrete lumps that reduce the electric field. As the voltage between electrodes is increased, the instability of liquid flow emerges which breaks the flow symmetry.

4. For the first time, the possibility of micro-bubble generation in high electric field on the electrode surface by the electrodynamic mechanism was confirmed by direct simulations. At certain conditions, the emergence of a region of gas phase was observed in computations. Such a bubble was

generated in the region of high electric field (near the tip) due to to electrodynamic cavitation. The electric breakdown of gas in bubbles generated can further result in the breakdown of liquid.

5. The model was developed which describes the streamer tip propagation and the dynamics of the electric discharge channel expansion in liquid with generation of shock waves. The planar and the cylindrical cases were considered.

   The divergent shock waves were observed at the streamer tip propagation with supersonic velocity and at the channel expansion due to energy release inside it.

6. The inner structure of the channel boundary (the transition layer "liquid–plasma") was computed taking into account the liquid viscosity. The non-monotonic pressure variation across the boundary due to viscous tension is shown. Theoretical estimates of the pressure step on the channel boundary and of the pressure peak inside the transition layer agree well with computation results.

Main results were presented on scientific conferences, among them:

- International Symposium on Electrical Insulation (Arlington, 1998)
- 13^{th} and 14^{th} International Conferences on Dielectric Liquids (Nara, 1999, Graz, 2002)
- 2^{nd} International Workshop on Electric Conduction, Convection and Breakdown of Liquids (Grenoble, 2000)
- 12^{th} Symposium on Combustion and Explosion (Chernogolovka, 2000)
- V and VI International Conferences "Modern Problems of Electrophysics and Electrohydrodynamics of Liquids" (Sankt-Petersburg, 1998, 2000)
- II, III, IV and V Siberian Workshops "Mathematical Problems of Fluid Mechanics" (Novosibirsk, 1998, 1999, 2000, 2001)
- International Conference "III Khariton's Topic Scientific Readings" (Sarov, 2001)
- International Conference "VI Zababakhin's Scientific Readings" (Sneginsk, 2001)
- III and IV International Workshops "Pulse Processes in Fluid Mechanics" (Nikolaev, 1999, 2001)

The results obtained are published in [1–14].

Bibliography

[1] A.L. Kupershtokh and D.A. Medvedev. Simulation of Gas-dynamic Flows during Streamer Propagation at Liquid Dielectrics Breakdown. In *Conference record of the 1998 IEEE Int. Symposium on Electrical Insulation*, pages 611–614, Arlington, VA, 1998.

[2] A.L. Kupershtokh and D.A. Medvedev. Modeling of gas-dynamic flows during streamer propagation at the breakdown of dielectric liquids. In *Modern problems of electrophysics and electrohydrodynamics of liquids (in russian). Proc. of V Int. Conference*, pages 126–130, Sankt-Petersburg, Russia, 1998.

[3] D.A. Medvedev and A.L. Kupershtokh. Lattice Boltzmann equation method for gas dynamics problems. In *Dinamika Sploshnoi Sredy (Dynamics of Continuous Medium)*, pages 117–121. N 114. Novosibirsk, Inst. of Hydrodynamics, 1999.

[4] D.A. Medvedev. Lattice Boltzmann equation method in problems of fluid dynamics. In *Proc. of III Workshop "Pulse processes in fluid mechanics, Nikolaev, Ukraine"*, pages 23–24. IIPT NAS Ukraine (in russian), 1999.

[5] A.P. Ershov, A.L. Kupershtokh, and D.A. Medvedev. Simulation of combustion waves in a porous medium by the cellular automata method. In V.K. Kedrinky, editor, *Dinamika Sploshnoi Sredy (Dynamics of Continuous Medium)*, pages 117–121. N 115. Novosibirsk, Inst. of Hydrodynamics, 1999.

[6] A.L. Kupershtokh and D.A. Medvedev. Simulation of Hydrodynamic Flows during Streamer Propagation in Dielectric Liquids. In *Proc. of 1999 IEEE 13th Int. Conference on Dielectric Liquids*, pages 179–182, Nara, Japan, 1999. IEEE N 99CH36213.

[7] A.L. Kupershtokh and D.A. Medvedev. Structure and dynamics of "plasma" channels at the breakdown of dielectric liquids. In *Dinamika*

Sploshnoi Sredy (Dynamics of Continuous Medium), pages 137–141. N 116. Novosibirsk, Inst. of Hydrodynamics, 2000.

[8] D.A. Medvedev and A.L. Kupershtokh. Use of the Lattice Boltzmann Equation Method to Simulate Charge Transfer and Electrohydrodynamic Phenomena in Dielectric Liquids. In P. Atten and A. Denat, editors, *Electrical Conduction, Convection and Breakdown in Fluids. Proc. 2nd Int. Workshop*, pages 60–63, Grenoble, France, 2000.

[9] A.P. Ershov, D.A. Medvedev, N.P. Satonkina, O.A. Dibirov, S.V. Tsykin, and Yu.V. Yanilikn. Mesoprocesses at detonation of TNT/RDX mixtures. In *Chemical physics of combustion and explosion processes. 12th Symposium on combustion and explosives. Part II*, pages 129–131. Chernogolovka: IPCP RAS, 2000 (in russian), 2000.

[10] A.P. Ershov, A.L. Kupershtokh, and D.A. Medvedev. Simulation of Convective Detonation Waves in a Porous Medium by the Lattice Gas Method. *Combustion, Explosion and Shock Waves*, 37(2):206–213, 2001. (Russian edition: Fizika Goreniya i Vzrywa, pp. 94–102).

[11] D.A. Medvedev, A.P. Ershov, and Yu.V. Yanilkin. Simulation of mixing in two-component system. In *Abstracts of Int. Conference "III Khariton's scientific readings"*, pages 184–186. Sarov, RFNC-VNIIEF (in russian), 2001.

[12] A.L. Kupershtokh and D.A. Medvedev. Lattice Boltzmann equation method for electrohydrodynamics. In *Dinamika Sploshnoi Sredy (Dynamics of Continuous Medium)*, pages 117–121. N 118. Novosibirsk, Inst. of Hydrodynamics, 2001.

[13] D.A. Medvedev and A.P. Ershov. Simulation of mixing of heterogeneous HE components behind the detonation front. In *Dinamika Sploshnoi Sredy (Dynamics of Continuous Medium)*, pages 126–129. Issue 118. Novosibirsk, Inst. of Hydrodynamics, 2001.

[14] D.A. Medvedev and A.L. Kupershtokh. Modeling of Electrohtdrodynamic Flows and Micro-bubbles Generation in Dielectric Liquid by Lattice Boltzmann Equation Method. In *Proc. of 2002 IEEE 14th Int. Conference on Dielectric Liquids*, pages 45–48, Graz, Austria, 2002. IEEE N 02CH37319.

[15] J. Hardy, O. de Pazzis, and Y. Pomeau. Molecular dynamics of a classical lattice gas: transport properties and time correlation functions. *Physical Review A*, 13(5):1949–1961, 1976.

[16] U. Frisch, B. Hasslacher, and Y. Pomeau. Lattice-gas automata for the Navier-Stokes equation. *Physical Review Letters*, 56(14):1505–1508, 1986.

[17] G. McNamara and G. Zanetti. Use of the Boltzmann equation to simulate lattice-gas automata. *Physical Review Letters*, 61(20):2332–2335, 1988.

[18] F.J. Higuera and J. Jiménez. Boltzmann approach to lattice gas simulation. *Europhysics Letters*, 9(7):663–668, 1989.

[19] A.P. Ershov. Gas dynamics of cellular automata (review). *Fizika Gorenia i Vzrywa (Combustion, Explosion and Shock Waves)*, 30(1):107–116, 1994. (Russian edition: pp. 107–117).

[20] S. Chen, M. Lee, K.H. Zhao, and G.D. Doolen. A lattice gas model with temperature. *Physica D*, 37:42–59, 1989.

[21] D. d'Humières, P. Lallemand, and U. Frisch. Lattice gas model for 3D hydrodynamics. *Europhysics Letters*, 2(4):291–297, 1986.

[22] D.H. Rothman and J.M. Keller. Immiscible Cellular-Automaton Fluids. *Journal of Statistical Physics*, 52(3/4):1119–1127, 1988.

[23] C. Appert and S. Zaleski. Lattice gas with a liquid-gas transition. *Physical Review Letters*, 64(1):1–4, 1990.

[24] D.H. Rothman and S. Zaleski. Lattice-gas models of phase separation: interfaces, phase transitions, and multiphase flow. *Reviews of Modern Physics*, 66(4):1417–1479, 1994.

[25] X. He and L.-S. Luo. A priori derivation of the lattice Boltzmann equation. *Physical Review E*, 55(6):6333–6336, 1997.

[26] T. Abe. Derivation of the lattice Boltzmann method by means of the discrete ordinate method for the Boltzmann equation. *Journal of Computational Physics*, 131(1):241–246, 1997.

[27] X. He, X. Shan, and G. Doolen. Discrete Boltzmann equation model for nonideal gases. *Physical Review E*, 57(1):R13–R16, 1998.

[28] L.-S. Luo. Unified theory of lattice Boltzmann models for nonideal gases. *Physical Review Letters*, 81(8):1618–1621, 1998.

[29] L.-S. Luo. Theory of the lattice Boltzmann method: Lattice Boltzmann models for nonideal gases. *Physical Review E*, 62(4):4982–4996, 2000.

[30] P. Bhatnagar, E.P. Gross, and M.K. Krook. A model for collision processes in gases. I. Small amplitude processes in charged and neutral one-component systems. *Physical Review*, 94(3):511–525, 1954.

[31] Y.H. Qian, D. d'Humières, and P. Lallemand. Lattice BGK models for Navier-Stokes equation. *Europhysics Letters*, 17(6):479–484, 1992.

[32] Y.H. Qian. Simulating thermohydrodynamics with lattice BGK models. *Journal of Scientific Computing*, 8(3):231–242, 1993.

[33] S. Chapman and T.G. Cowling. *The Mathematical Theory of Nonuniform Gases*. Cambridge University Press, 1970.

[34] Y.H. Qian and S.A. Orszag. Lattice BGK models for the Navier-Stokes equation: nonlinear deviation in compressible regimes. *Europhysics Letters*, 21(3):255–259, 1993.

[35] P.J. Dellar. Bulk and shear viscosities in lattice Boltzmann equation. *Physical Review E*, 64:031203–1–031203–11, 2001.

[36] S. Chen and G. Doolen. Lattice Boltzmann method for fluid flows. *Annual Review of Fluid Mechanics*, 30:329–364, 1998.

[37] Y.H. Qian. Fractional propagation and the elimination of staggered invariants in lattice-BGK models. *International Journal of Modern Physics C*, 8(4):753–762, 1997.

[38] R. Zhang, H. Chen, Y.H. Qian, and S. Chen. Effective volumetric lattice Boltzmann scheme. *Physical Review E*, 63:056705–1–056705–6, 2001.

[39] S. Hou, Q. Zou, S. Chen, G. Doolen, and A.C. Cogley. Simulation of cavity flow by the lattice Boltzmann method. *Journal of Computational Physics*, 118(2):329–347, 1995.

[40] X. He and G. Doolen. Lattice Bolzmann method on curvilinear coordinates system: Flow around a circular cylinder. *Journal of Computational Physics*, 134(2):306–315, 1997.

[41] D.O. Martinez, W.H. Matthaeus, S. Chen, and D.C. Montgomery. Comparison of spectral method and lattice Boltzmann simulations of two-dimensional hydrodynamics. *Physics of Fluids*, 6(3):1285–1298, 1994.

[42] X. He, L.-S. Luo, and M. Dembo. Some progress in lattice Boltzmann method. Part I. Nonuniform mesh grids. *Journal of Computational Physics*, 129(2):357–363, 1996.

[43] F. Nannelli and S. Succi. The lattice Boltzmann equation on irregular lattices. *Journal of Statistical Physics*, 68(3/4):401–407, 1992.

[44] G. Amati, S. Succi, and R. Benzi. Turbulent channel flow simulations using a coarse-grained extension of the lattice Boltzmann method. *Fluid Dynamics Research*, 19:289–302, 1997.

[45] O. Filippova and D. Hänel. Grid refinement for lattice-BGK models. *Journal of Computational Physics*, 147:219–228, 1998.

[46] O. Filippova and D. Hänel. Acceleration of lattice-BGK schemes with grid refinement. *Journal of Computational Physics*, 165:407–427, 2000.

[47] C.-L. Lin and Y.G. Lai. Lattice Boltzmann method on composite grids. *Physical Review E*, 62(2):2219–2225, 2000.

[48] S. Chen, H. Chen, D. Martinez, and W. Matthaeus. Lattice Boltzmann model for simulation of magnetohydrodynamics. *Physical Review Letters*, 67(27):3776–3779, 1991.

[49] S. Succi, M. Vergasola, and R. Benzi. Lattice Boltzmann scheme for two-dimensional magnetohydrodynamics. *Physical Review A*, 43(8):4521–4524, 1991.

[50] Y.H. Qian and Y.F. Deng. A lattice BGK model for viscoelastic media. *Physical Review Letters*, 79(14):2742–2745, 1997.

[51] O. Dardis and J. McCloskey. Lattice Boltzmann scheme with real numbered solid density for the simulation of flow in porous media. *Physical Review E*, 57(4):4834–4837, 1998.

[52] F.J. Alexander, S. Chen, and J.D. Sterling. Lattice Boltzmann thermohydrodynamics. *Physical Review E*, 47(4):R2249–R2252, 1993.

[53] Y. Chen, H. Ohashi, and M. Akiyama. Thermal lattice Bhatnagar-Gross-Krook model without nonlinear deviations in macrodynamical equations. *Physical Review E*, 50(4):2776–2783, 1994.

[54] Y. Chen, H. Ohashi, and M. Akiyama. Heat transfer in lattice BGK modelled fluids. *Journal of Statistical Physics*, 81(1/2):71–85, 1995.

[55] M. Soe, G. Vahala, P. Pavlo, L. Vahala, and H. Chen. Thermal lattice Boltzmann simulations of variable Prandtl number turbulent flows. *Physicl Review E*, 57(4):4227–4237, 1998.

[56] P. Pavlo, G. Vahala, and L. Vahala. Higher order isotropic velocity grids in lattice methods. *Physical Review Letters*, 80(18):3960–3963, 1998.

[57] N. Cao, S. Chen, S. Jin, and D. Martinez. Physical symmetry and lattice symmetry in the lattice Boltzmann method. *Physical Review E*, 55(1):R21–R24, 1997.

[58] A. Renda, G. Bella, S. Succi, and I.V. Karlin. Thermohydrodynamic lattice BGK schemes with non-perturbative equilibria. *Europhysics Letters*, 41(3):279–283, 1998.

[59] X. Shan. Simulation of Rayleigh–Bénard convection using a lattice Boltzmann method. *Physical Review E*, 55(3):2780–2788, 1997.

[60] X. He, S. Chen, and G.D. Doolen. A novel thermal model for the lattice Boltzmann method in incompressible limit. *Journal of Computational Physics*, 146(2):282–300, 1998.

[61] B.J. Palmer and D.R. Rector. Lattice Boltzmann algorithm for simulating thermal flow in compressible fluids. *Journal of Computational Physics*, 161(1):1–20, 2000.

[62] G.R. McNamara, A.L. Garcia, and B.J. Alder. Stabilization of Thermal Lattice Boltzmann Models. *Journal of Statistical Physics*, 81(1/2):395–408, 1995.

[63] F.L. Hinton, M.N. Rosenbluth, S.K. Wong, Y.R. Lin-Liu, and R.L. Miller. Modified lattice Boltzmann method for compressible fluid simulations. *Physical Review E*, 63:061212–1–061212–9, 2001.

[64] A.K. Gunstensen, D.H. Rothman, S. Zaleski, and G. Zanetti. Lattice Boltzmann model of immiscible fluids. *Physical Review A*, 43(8):4320–4327, 1991.

[65] D. Grunau, S. Chen, and K. Eggert. A lattice Boltzmann model for multiphase fluid flows. *Physics of Fluids A*, 5(10):2557–2562, 1993.

[66] R. Holme and D.H. Rothman. Lattice-gas and lattice-Boltzmann models of miscible fluids. *Journal of Statistical Physics*, 68(3/4):409–429, 1992.

[67] X. Shan and H. Chen. Lattice Boltzmann model for simulating flows with multiple phases and components. *Physical Review E*, 47(3):1815–1819, 1993.

[68] X. Shan and H. Chen. Simulation of nonideal gases and liquid-gas transitions by the lattice Boltzmann equation. *Physical Review E*, 49(4):2941–2948, 1994.

[69] X. Shan and G. Doolen. Multicomponent lattice-Boltzmann model with interparticle interaction. *Journal of Statistical Physics*, 81(1/2):379–393, 1995.

[70] X. Shan and G. Doolen. Diffusion in a multicomponent lattice Boltzmann equation model. *Physical Review E*, 54(4):3614–3620, 1996.

[71] S. Ponce Dawson, S. Chen, and G.D. Doolen. Lattice Boltzmann computations for reaction-diffusion equations. *Journal of Chemical Physics*, 98(2):1514–1523, 1993.

[72] X. He, R. Zhang, S. Chen, and G.D. Doolen. On the three-dimensional Rayleigh-Taylor instability. *Physics of Fluids*, 11(5):1143–1152, 1999.

[73] G.M. Mamontov, V.V. Mitrofanov, and V.A. Subbotin. Detonation regimes of the gaseous mixture in inert porous medium. In *Detonation. Proc. VI All-Union Symp. on Combustion and Explosion*, pages 106–110, Chernogolovka, 1980. (in Russian).

[74] G.A. Lyamin. Heterogeneous detonation in a rigid porous medium. *Fizika Gorenia i Vzrywa (Combustion, Explosion and Shock Waves)*, 20(6):134–138, 1984.

[75] G.A. Lyamin and A.V. Pinaev. Fuel properties effect on the heterogeneous detonation parameters in a porous medium. In *Dinamica Sploshnoi Sredy (Dynamics of Continuous Medium)*, pages 95–101. N 88. Novosibirsk, Inst. of Hydrodynamics, 1988.

[76] A.V. Pinaev and G.A. Lyamin. To the structure of gas-film and gaseous detonation in an inert porous medium. *Fizika Gorenia i Vzrywa (Combustion, Explosion and Shock Waves)*, 28(5):97–102, 1992.

[77] G.A. Lyamin and A.V. Pinaev. Heterogeneous detonation (gas-film) in porous medium. The region of existence and limits. *Fizika Gorenia i Vzrywa (Combustion, Explosion and Shock Waves)*, 28(5):102–108, 1992.

[78] A.V. Pinaev and G.A. Lyamin. Low-velocity detonation of high explosive in evacuated porous medium. *Doclady RAN*, 325(3):498–501, 1992.

[79] V.V. Andreev and L.A. Lukyanchikov. To the propagation mechanizm of low-velocity detonation in powdered PETN after spark initiation. *Fizika Gorenia i Vzrywa (Combustion, Explosion and Shock Waves)*, 10(6):912–919, 1974.

[80] V.V. Andreev, A.P. Ershov, and L.A. Lukyanchikov. Two-phase low-velocity detonation of a porous explosive. *Fizika Gorenia i Vzrywa (Combustion, Explosion and Shock Waves)*, 20(3):89–93, 1984.

[81] A.P. Ershov. Isothermal detonation and its stochastic modeling. *Fizika Gorenia i Vzrywa (Combustion, Explosion and Shock Waves)*, 30(3):366–376, 1994. (Russian edition: pp. 112–124).

[82] A.P. Ershov, A.L. Kupershtokh, and A.Ya. Dammer. Structured flows in porous media modeling by stochastic methods. In C.T. et al Crowe, editor, *Numerical Methods for Multiphase Flows. Proc. Int. Symp. on Multiphase Flows*, pages 59–64, Lake Tahoe, NV, 1994. N.Y.: ASME, FED-Vol. 185,.

[83] S. Ergun. Fluid flow through packed columns. *Chem. Eng. Progr.*, 48(2):89–94, 1952.

[84] D.P. Jones and H. Krier. Gas flow resistance measurements through packed beds at high Reynolds numbers. *Trans. ASME. Journal of Fluid Engineering*, 105:168–173, 1983.

[85] W.H. Denton. The heat transfer and flow resistance for fluid flow through randomly packed spheres. In *General Discussion on Heat Transfer.*, pages 370–373. London. Institute of Mechanical Engineering and ASME, 1951.

[86] A.P. Ershov. A convective detonation wave in a porous structure. *Fizika Gorenia i Vzrywa (Combustion, Explosion and Shock Waves)*, 33(1):81–88, 1997. (Russian edition: pp. 98–106).

[87] J.-F. Haas and B Sturtevant. Interaction of weak shock waves with cylindrical and spherical gas inhomogeneities. *Journal of Fluid Mechanics*, 181(1):41–76, 1987.

[88] N. Cowperthwaite. The interaction of a plane shock and a dense spherical inhomogeneity. *Physica D*, 37(1-3):264–269, 1989.

[89] J.W. Jacobs. The dynamics of shock accelerated light and heavy gas cylinders. *Physics of Fluids*, 5(9):2239–2247, 1993.

[90] M.A. Jones and J.W. Jacobs. A membraneless experiment for the study of Richtmyer–Meshkov instability of a shock-accelerated gas interface. *Physics of Fluids*, 9(10):3078–3085, 1997.

[91] O. Sadot, U. Alon, D. Oron, L. A. Levin, G. Erez, G. Ben-Dor, and D. Shvarts. Study of nonlinear evolution of single-mode and two-bubble interaction under Richtmyer–Meshkov instability. *Physical Review Letters*, 80(8):1654–1657, 1998.

[92] P.M. Rightley, P. Vorobieff, R. Martin, and R.F. Benjamin. Experimental observations of the mixing transitions in a shock-accelerated gas curtain. *Physics of Fluids*, 11(1):186–200, 1999.

[93] R.L. Holmes, G. Dimonte, B. Fryxell, M.L. Gittings, J.W. Growe, R. Schneider, D.H. Sharp, A.L. Velikovich, R.P. Weaver, and O. Zhang. Richtmyer–Meshkov instability growth: experiment, simulation and theory. *Journal of Fluid Mechanics*, 389:55–79, 1999.

[94] P. Clavin, P. Lallemand, Y. Pomeau, and G. Searby. Simulation of free boundaries in flow systems by lattice-gas models. *Journal of Fluid Mechanics*, 188:437–464, 1988.

[95] A.K. Gunstensen and D.H. Rothman. A Galilean-invariant immiscible lattice gas. *Physica D*, 47:53–63, 1991.

[96] H. Xi and G. Duncan. Lattice Boltzmann simulations of three-dimensional single droplet deformation and breakup under simple shear flow. *Physical Review E*, 59(3):3022–3026, 1999.

[97] A.P. Ershov, N.P. Satonkina, O.A. Dibirov, S.V. Tsykin, and Yu.V. Yanilkin. A study of the interaction between the components of heterogeneous explosives by the electrical-conductivity method. *Fizika Gorenia i Vzrywa (Combustion, Explosion and Shock Waves)*, 36(5):639–649, 2000.

[98] V.M. Titov, V.V. Mitrofanov, A.P. Ershov, A.L. Kupershtokh, and I.Yu. Mal'kov. Carbon in detonation processes (part B). Report done for Livermore laboratory, Institute of Hydrodynamics SB RAS, Novosibirsk, 1994. 69 p.

[99] O.N. Davydova, N.M. Kuznetsov, V.V. Lavrov, and K.K. Shvedov. On undercompressed detonation of condensed HEs with inert ingredients. *Khimicheskaja Fizika (Chemical Physics)*, 18(4):53–66, 1999.

[100] D.I. Karpov and A.L. Kupershtokh. Models of Streamer Growth with "Physical" Time and Fractal Characteristics of Streamer Structures. In *Conference record of the 1998 IEEE Int. Symposium on Electrical Insulation*, pages 607–610, Arlington, VA, 1998.

[101] P.A. Vázquez, A.T. Pérez, A. Castellanos, and P. Atten. Dynamics of electrohydrodynamic laminar plumes: Scaling analysis and integral model. *Physics of Fluids*, 12(11):2809–2818, 2000.

[102] P.K. Watson, W.G. Chadband, and M. Sadeghzadeh-Araghi. The role of electrostatic and hydrodynamic forces in the negative-point breakdown of liquid dielectrics. *IEEE Transactions on Electrical Insulation*, 26(4):543–559, 1991.

[103] H. Yamashita, K. Yamazawa, W. Machidori, and Y.S. Wang. The effect of tip curvature on the prebreakdown density change streamer in cyclohexane. In *Proc. of the 12th Int. Conf. on Conduction and Breakdown in Dielectric Liquids*, pages 226–229, Roma, Italy, 1996. IEEE N 96CH35981.

[104] F.J. Higuera. Electrohydrodynamic flow of a dielectric liquid around a blade electrode. *Physics of Fluids*, 12(11):2732–2742, 2000.

[105] C.G. Garton and Z. Krasuzki. Bubbles in insulating liquids: stability in an electric field. *Proceedings of Royal Society*, A280(1381):211–226, 1964.

[106] A. Beroual. Behaviour of charged and uncharged bubbles in dielectric liquids subjected to electric stress. *Journal of Applied Physics*, 71(3):1142–1145, 1992.

[107] S.M. Korobeinikov. The Role of Bubbles in the Electric Breakdown of Liquids: Prebreakdown Processes. *High Temperature*, 36(3):362–367, 1998.

[108] S.M. Korobeynikov, A.V. Melekhov, V.G. Posukh, V.M. Antonov, and Yu.N. Sinikh. Deformation and motion of bubbles at action of strong fields. In *Modern problems of electrophysics and electrohydrodynamics of liquids (in russian). Proc. of VI Int. Conference*, pages 187–190, Sankt-Petersburg, Russia, 2000.

[109] S.M. Korobeinikov. The Role of Bubbles in the Electric Breakdown of Liquids: Comparison with Experiment. *High Temperature*, 36(4):541–547, 1998.

[110] V. Giraud and P. Krebs. The onset of electron localization in subcritical water vapour. *Chemical Physics Letters*, 86(1):85–90, 1982.

[111] H.M. Jones and E.E. Kunhardt. Development of pulsed dielectric breakdown in liquids. *Journal of Physics D: Applied Physics*, 28(1):178–188, 1995.

[112] Z. Krasucki. Breakdown of liquid dielectrics. *Proceedings of Royal Society*, A294(1438):393–404, 1966.

[113] M. Sadeghzadeh-Araghi, M.I. Qureshi, W.G. Chadband, and P.K. Watson. Measurement of the growth of cavities and of EHD instabilities during the negative-point breakdown of silicon fluids. *IEEE Transactions on Electrical Insulation*, 26(4):663–672, 1991.

[114] V.R. Kukhta, V.V. Lopatin, and M.D. Noskov. Fractal Features of Near-Electrode Formations under Electric Discharge in Water. *Izvestija Vysshikh Uchebnykh Zavedeniy. Fizika (Russian Physics Journal)*, (7):89–92, 1994.

[115] B. Halpern and R. Gomer. Field emission in liquids. *Journal of Chemical Physics*, 51(3):1031–1047, 1969.

[116] O.A. Sinkevich and P.V. Smirnov. Heterogeneous mechanism of electrical breakdown of liquid dielectrics. *Journal of Moscow Physical Society*, 6:101, 1996.

[117] S.M. Korobeinikov. Injection Current and the Formation of Bubbles in Strong, Very Nonuniform Electric Fields. *Journal of Applied Mechanics and Technical Physics*, 41(5):831–835, 2000. (Russian edition: Prikladnaya Mekhanika i Tekhnicheskaya Fizika, pp. 75–80).

[118] P. Gournay and O. Lesaint. On the gaseous nature of positive filamentary streamers in hydrocarbon liquids. II: Propagation, growth and collapse of gaseous filaments in pentane. *Journal of Physics D: Applied Physics*, 27:2117–2127, 1994.

[119] J. Barrett and A.L. Mansell. Ultra-violet absorption spectra of the molecules H_2O, HDO and D_2O. *Nature*, 187:138–141, 1960.

[120] A.L. Kupershtokh. Investigation of non-ideal plasma generated in the channel of electric discharge in water. In *Proc. of the 15th Int. Conf. on Phenomena in Ionized Gases*, pages 345–346, Minsk, USSR, 1981.

[121] P. Bårmann, S. Kröll, and A. Sunesson. Spatially and temporally resolved electron density measurements in streamers in dielectric liquids. *Journal of Physics D: Applied Physics*, 30(5):856–863, 1997.

[122] V.V. Arsent'ev. On theory of pulse discharges in liquid. *Journal of Applied Mechanics and Technical Physics*, (5):34–37, 1965.

[123] I.Z. Okun'. Calculation of pressure acting on a piston at its constant expansion velocity. *Izv. Akad. Nauk SSSR, Mekh. Zhidk. Gaza*, (1):126–130, 1968.