PSAAPII Publications Report — August 2018

# XPACC: The Center for Exascale Simulation of Plasma-Coupled Combustion


W. D. Gropp
J. B. Freund

D. J. Bodony G. S. Elliott L. N. Olson

N. G. Glumac W.-M. Hwu H. T. Johnson
A. P. E. Klöckner L. V. Kale T. Lee
D. A. Padua M. Panesi C. Pantano
M. Snir K. A. Stephani

**Parallel Computing Institute**
**University of Illinois at Urbana-Champaign**

I. V. Adamovich

**The Ohio State University**


This report provides a listing of XPACC publications (page 2) and presentations (page 10).

## XPACC Publications


[1] I. V. Adamovich, T. Li, and W. R. Lempert. Kinetic mechanism of molecular energy transfer and chemical reactions in low-temperature air-fuel plasmas. *Philosophical Transactions of the Royal Society A*, 373:20140336, 2015.

[2] A. Alberti, A. Munafò, A. Sahai, C. Pantano, and M. Panesi. FEM simulation of laser-induced plasma breakdown experiments for combustion applications. AIAA Paper 2017–1111, 2017. 55th AIAA Aerospace Sciences Meeting.

[3] E. Baratte, I. V. Adamovich, M. Simeni Simeni, and K. Frederickson. Measurements of electric field in a nanosecond pulse discharge by 4-wave mixing. In *72nd International Symposium on Molecular Spectroscopy*, pages 19–23, 2017.

[4] N. N. Beams, L. N. Olson, and J. B. Freund. A scalable fast method for n-body problems based on exact finite element basis screen functions. *SIAM J. Sci. Comp.*, 38(3):A1538–A1560, 2016.

[5] D. Buchta, R. Vishnampet, D. J. Bodony, and J. B. Freund. A discrete adjoint-based shape optimization for shear-layer-noise reduction. AIAA Paper 2016-2776, 2016.

[6] Y. c. Hung, C. Winters, E. Jans, K. Frederickson, and I. V. Adamovich. $N_2$ vibrational temperature and OH number density measurements in a ns pulse discharge hydrogen-air plasmas. In *72nd International Symposium on Molecular Spectroscopy*, pages 19–23, Illinois, 2017.

[7] J. Capecelatro, D. J. Bodony, and J. B. Freund. Adjoint-based sensitivity analysis of ignition in a turbulent reactive shear layer. AIAA Paper 2017-0846, 2017.

[8] J. Capecelatro, D. J. Bodony, and J. B. Freund. Adjoint-based sensitivity and ignition threshold mapping in a turbulent mixing layer. *Combustion Theory and Modeling*, 23:1–35, 2018.

[9] J. Capecelatro, R. Vishnampet, T. Wada, N. Glumac, G. Elliot, D. Bodony, and J. B. Freund. Adjoint-based sensitivity analysis of localized ignition in a non-premixed hydrogen/air mixing layer. 54th AIAA Aerospace Sciences Meeting (SciTech 2016). AIAA Paper 2016-2153, Janurary 2016.

[10] L. Chang, I. El Hajj, H. Kim, J. Gómez-Luna, A. Dakkak, and W. Hwu. A programming system for future proofing performance critical libraries. *PPoPP*, 2016.

[11] L. Chang, H. Kim, and W. Hwu. DySel: Lightweight dynamic selection for kernel-based data-parallel programming model. *ASPLOS*, 2016.

[12] K. Das, J. B. Freund, and H. T. Johnson. Mechanisms of material removal and mass transport in focused ion beam nanopore formation. *J. App. Phys.*, 117:085304, 2015.

[13] K. Das, J. B. Freund, and H. T. Johnson. Erosive-thermal transition in high-flux focused ion beam nanomachining of surfaces. *Extreme Mechanics Letters*, 7:121–125, 2016.

[14] K. Das, H. T. Johnson, and J. B. Freund. Atomic-scale thermocapillary flow in focused ion beam milling. *Phys. Fluids*, 27:052003, 2015.

[15] M. Diener, D. J. Bodony, and L. Kale. Accelerating scientific applications on heterogeneous systems with HybridOMP. In *Lecture Notes in Computer Science*. Springer, 2018.

[16] Matthias Diener, Sam White, and Laxmikant V. Kale. Visualizing, measuring, and tuning adaptive MPI parameters. In *Proceedings of the Fourth International Workshop on Visual Performance Analysis*, VPA, 2017.

[17] Matthias Diener, Sam White, Laxmikant V. Kale, Michael Campbell, Daniel J. Bodony, and Jonathan B. Freund. Improving the memory access locality of hybrid MPI applications. In *Proceedings of the 24th European MPI Users' Group Meeting*, EuroMPI, 2017.

[18] Z. Eckert. *Energy Transfer in Non-Equilibrium Reacting Gas Flows: Applications in Plasma Assisted Combustion and Chemical Gas Lasers*. PhD thesis, Ohio State University, 2017.

[19] Z. Eckert, N. Tsolas, K. Togai, A. Chernukho, R. A. Yetter, and I. V. Adamovich. Kinetics of plasma-assisted oxidation of highly diluted hydrocarbon mixtures excited by a repetitive nanosecond pulse discharge. *Journal of Physics D: Applied Physics*, 51:374002, 2018.

[20] R. A. Fontaine, J. E. Retter, J. B. Freund, N. G. Glumac, and G. S. Elliott. Ignition, sustained flame, and extinction of a dielectric-barrier-discharge altered hydrogen jet in a cross-flow. 54th AIAA Aerospace Sciences Meeting (SciTech 2016). AIAA Paper 2016-0453, January 2016.

[21] K. Frederickson, E. Jans, M. Huang, I. Gulko, T. A. Miller, and I. V. Adamovich. Measurements of radical and metastable species in nonequilibrium plasmas by cavity ring-down spectroscopy. AIAA Paper2018-0687 AIAA Aerospace Sciences Meeting, Kissimmee, FL, 2018.

[22] J. B. Freund and R. H. Ewoldt. Quantitative rheological model selection: Good fits versus credible models using Bayesian inference. *J. of Rheology*, 59:667–701, 2015.

[23] S. Garcia De Gonzalo, C. Pearson, I. El Hajj, and W Hwu. Effective use of accelerators. In *NCSA Blue Waters Symposium for Petascale Science and Beyond*, Sunriver, Oregon, May 2015.

[24] Simon Garcia De Gonzalo, Simon Hammond, Christian Trott, and Wen-Mei Hwu. Revisiting online autotuning for sparse-matrix vector multiplication kernels on next-generation architectures. In *Proceedings of the 19th IEEE International Conference on High Performance Computing and Communications*, HPCC'17, 2017.

[25] P. Ghale and H. T. Johnson. Density matrix computations for large systems using SpMVs. Workshop on Materials Computation: data science and multiscale modeling, August 2017.

[26] P. Ghale and H. T. Johnson. A sparse matrix-vector multiplication based algorithm for accurate density matrix computations on systems of millions of atoms. *Comp. Phys. Commun.*, Accepted for publication, 2018.

[27] P. Ghale, M. P. Kroonblawd, S. Mniszewski, C. F. A. Negre, R. Pavel, S. Pino, V. Sardeshmukh, G. Shi, and G. Hahn. Task-based parallel computation of the density matrix in quantum-based molecular dynamics using graph partitioning. *SIAM J. Sci. Comput.*, 39, 2017.

[28] P. Ghale, M. P. Kroonblawd, S. Mniszewski, Ch. F. A. Negre, R. Pavel, S. Pino, V. Sardeshmukh, G. Shi, and G. Hahn. Task-based parallel computation of the density matrix in quantum-based molecular dynamics using graph partitioning. Salishan Conference on High Speed Computing, April 2016.

[29] B. Goldberg, I. Shkurenkov, I. V. Adamovich, and W. R. Lempert. Electric field vector measurements in an AC dielectric barrier discharge overlapped with a nanosecond pulse discharge. *Plasma Sources Science and Technology*, 25:045008, 2016.

[30] B. M. Goldberg, I. Shkurenkov, I. V. Adamovich, and W. R. Lempert. Electric field measurements in a plane-to-plane AC dielectric barrier discharge with nanosecond pulse discharge enhancement. AIAA Paper 2016-1215, 2016.

[31] B. M. Goldberg, I. Shkurenkov, S. O'Byrne, I. V. Adamovich, and W. R. Lempert. Electric field measurements in a dielectric barrier nanosecond pulse discharge with sub-nanosecond time resolution. 53rd AIAA Aerospace Sciences Meeting (SciTech 2015), AIAA Paper 2015-0935.

[32] B. M. Goldberg, I. Shkurenkov, S. O'Byrne, I. V. Adamovich, and W. R. Lempert. Electric field measurements in a dielectric barrier nanosecond pulse discharge with sub-nanosecond time resolution. *Plasma Sources Science and Technology*, 24:035010, 2015.

[33] B. M. Goldberg, M. Simeni Simeni, C. Zhang, H. Takana, and I. V. Adamovich. Four-wave mixing measurements and kinetic modeling predictions of electric field in a quasi-two-dimensional ns pulse discharge in air. In *13th International Conference on Flow Dynamics*, pages 10–12, Japan, 2016. October Sendai.

[34] A. Harpale, M. Panesi, and H. B. Chew. Surface-to-bulk diffusion of isolated versus interacting C atoms in Ni(111) and Cu(111) substrates: A first principle investigation. *Journal of Chemical Physics: Communication*, 142:061101, 2015.

[35] K. L. Heritier, R. L. Jaffe, V. Laporta, and M. Panesi. Energy transfer models in nitrogen plasmas: Analysis of N2-N-e interaction. *Journal of Chemical Physics*, 141:184302, 2014.

[36] Huda Ibeid, Luke Olson, and William Gropp. Fft, fmm, and multigrid on the road to exascale: performance challenges and opportunities. *Journal of Parallel and Distributed Computing*, 2018. in review.

[37] G. Elliott. J. Retter. Investigations on a DBD burner: corrected filtered rayleigh scattering by means of spontaneous raman scattering. AIAA Paper 2018-0933, 2018.

[38] P. Jha and L. Massa. Teaching thermochemical equilibrium using a MATLAB code. *Computer in Education Journal*, July - September, 2014.

[39] H.-S. Kim, I. El Hajj, J. Stratton, S. Lumetta, and W.-M. Hwu. Locality-centric thread scheduling for bulk-synchronous programming models on CPU architectures. In *Code Generation and Optimization (CGO), 2015 IEEE/ACM International Symposium on*, pages 257–268, Feb 2015.

[40] Andreas Klöckner. Loo.py: transformation-based code generation for GPUs and CPUs. *CoRR*, abs/1405.7470, 2014.

[41] Andreas Kloeckner. Loo.py: From Fortran to performance via transformation and substitution rules. Proceedings of ARRAY 2015: ACM SIGPLAN Workshop on Libraries, Languages, and Compilers for Array Programming, June 2015.

[42] R. Knaus and C. Pantano. A computational approach to flame hole dynamics using an embedded manifold approach. *Journal of Computational Physics*, 296:209–240, 2015.

[43] D. Kotov, H. Yee, M. Panesi, D. Prabhu, and A. Wray. Computational challenges for simulations related to the NASA electric arc shock tube (EAST) experiments. *Journal of Computational Physics*, 269:215–233, 2014.

[44] Gyu Sub Lee, Qili Liu, Damiano Baccarella, Gregory S. Elliott, and Tonghun Lee. *A Novel Supersonic Injection Scheme for Laser Induced Breakdown Ignition.* American Institute of Aeronautics and Astronautics, 2018.

[45] Y. Liu, M. Panesi, A. Sahai, and M. Vinokour. Generalized multi-group macroscopic modeling for thermo-chemical non-equilibrium gas mixtures. *Journal of Chemical Physics*, 142:134109, 2015.

[46] Y. Liu, M. Panesi, A. Sahai, and M. Vinokur. General multi-group macroscopic modeling for thermo-chemical non-equilibrium gas mixtures. *Journal Chemical Physics*, –:–, 2014. Under Review.

[47] K. Mackay, J. B. Freund, and H. T. Johnson. Poisoning of hydrogen recombination on silica due to water adsorption. *J. Phys. Chem. C*, 121(30):16366–16372, 2017.

[48] K. K. Mackay, J. B. Freund, and H. T. Johnson. Hydrogen recombination rates on silica from atomic-scale calculations. *Journal of Physical Chemistry C*, 120:24137–24147, 2016.

[49] Kyle K. Mackay, Jonathan B. Freund, and Harley T. Johnson. Enhancement of hydrogen microcombustion via field-emission dielectric barrier discharge. *Plasma Sources Science and Technology*, 27(8):085007, Aug 2018.

[50] Saeed Maleki, G. Carl Evans, and David A. Padua. Tiled linear algebra a system for parallel graph algorithms. In *Proceedings of the 27rd International Conference on Languages and Compilers for Parallel Computing*, LCPC'14, 2014.

[51] L. Massa and J. B. Freund. An integrated predictive simulation model for the plasma-assisted ignition of a fuel jet in a turbulent crossflow. 54th AIAA Aerospace Sciences Meeting (SciTech 2016). AIAA Paper 2016-2154, Janurary 2016.

[52] L. Massa and J. B. Freund. Plasma-combustion coupling in a dielectric-barrier discharge actuated fuel jet. *Comb. and Flame*, 184:208–232, 2017.

[53] L. Massa, J. Retter, G. S. Elliott, and J. B. Freund. Plasma-combustion coupling in a dielectric-barrier discharge actuated fuel jet. AIAA Paper 2017-3675, 2017.

[54] L. Massa, J. E. Retter, G. S. Elliott, and J. B. Freund. Dielectric-barrier-discharge plasma-assisted hydrogen diffusion flame. part 2: Modeling and comparison with experiments. *Combustion and Flame*, 191:541–557, 2018.

[55] L. L. Massa and J. B. Freund. Plasma-combustion coupling in a dielectric-barrier discharge actuated fuel jet. AIAA Paper 2017-0391, 2017.

[56] Luca L. Massa, Jon Retter, Gregory S. Elliott, and Jonathan B. Freund. *Effect of Dielectric Barrier Discharge Body Forces on Hydrogen Flames*. American Institute of Aeronautics and Astronautics, 2018/08/23 2017.

[57] K. Miki, M. Panesi, and S. Prudhomme. Systematic validation of non-equilibrium thermochemical models using Bayesian inference. *Journal Computational Physics*, –:–, 2014. Under Review.

[58] K Miki, M. Panesi, and S. Prudhomme. Systematic validation of non-equilibrium thermochemical models using bayesian approach. *Journal of Computational Physics*, 298:125–144, 2015.

[59] Cory Mikida, Andreas Klöckner, and Daniel Bodony. Multi-rate time integration on overset meshes. 2018. Submitted to Journal of Computational Physics.

[60] A. Munafò, A. Alberti, C. Pantano, J. B. Freund, and M. Panesi. Modeling of laser-induced breakdown phenomena in non-equilibrium plasmas. AIAA Paper 2018-0171, 2018.

[61] A. Munafò, M. Panesi, and T. E. Magin. Boltzmann rovibrational collisional coarse-grained model for internal energy excitation and dissociation in hypersonic flows. *Physical Review E*, 23:023001, 2014.

[62] M. Natarajan, J. B. Freund, and D. J. Bodony. Actuator election and placement for localized feedback flow control. *J. Fluid Mech.*, 809:775–792, 2016.

[63] M. Natarajan, J. B. Freund, and D. J. Bodony. Control of supersonic jet noise using linear feedback. 22nd AIAA/CEAS Aeroacoustics Conference, AIAA Paper 2016-3055, 2016.

[64] M. Natarajan, J. B. Freund, and D. J. Bodony. Global mode based control of supersonic jet noise. AIAA Paper 2016-3055, 2016.

[65] M. Natarajan, J. B. Freund, and D. J. Bodony. Global mode based control of supersonic jet noise. 8th AIAA Flow Control Conference, AIAA Paper 2016-3258, 2016.

[66] M. Natarajan, J. B. Freund, and D. J. Bodony. Global mode-based control of laminar and turbulent high-speed jets. *Accepted for publication in a special issue of Comptes Rendus Mé chanique on jet noise*, 2018.

[67] M. Nishihara, J. B. Freund, N. G. Glumac, and G. S. Elliott. Dual-pump cars measurements in a hydrogen diffusion flame in cross-flow with ac dielectric barrier discharge. *Plasma Sources Science and Technology*, 27:0350123, 2018.

[68] M. Nishihara, J. B. Freund, N. G. Glumac, and G. S. Elliott. Inuence of mode-beating pulse on laser-induced plasma. *Journal of Physics D: Applied Physics*, 51:135601, 2018.

[69] M. Panesi, A. Munafò, T. E. Magin, and R. L. Jaffe. Non-equilibrium shock-heated nitrogen flows using a rovibrational state-to-state method. *Physical Review E*, 90:013009, 2014.

[70] V. Petrishchev, Z. Yin, C. Winters, S. B. Leonov, W. R. Lempert, and I. V. Adamovich. Surface charge dynamics and OH and H number density distributions in near-surface nanosecond pulse discharges at a liquid / vapor interface. 53rdAIAA Aerospace Sciences Meeting (SciTech 2015), AIAA Paper 2015-0934, 2015.

[71] Tarun Prabhu and William Gropp. DAME: A runtime-compiled engine for derived datatypes. In Jack J. Dongarra, Alexandre Denis, Brice Goglin, Emmanuel Jeannot, and Guillaume Mercier, editors, *Proceedings of the 22nd European MPI Users' Group Meeting, EuroMPI 2015, Bordeaux, France, September 21-23, 2015*, pages 4:1–4:10. ACM, 2015.

[72] Tarun Prabhu and William Gropp. Moya — a jit compiler for hpc. In *Proceedings of the 6th Workshop on Extreme-Scale Programming Tools*, ESPT '17, 2017.

[73] A. Reisner, L. Olson, and J. D. Moulton. Scaling structured multigrid to 500k+ cores through coarse-grid redistribution. *SIAM Journal on Scientific Computing*, 40(4):C581–C604, 2018.

[74] J. E. Retter, G. S. Elliott, and S. P. Kearney. Dielectric-barrier-discharge plasma-assisted hydrogen diffusion flame. part 1: Temperature, oxygen, and fuel measurements by one-dimensional cars imaging. *Combustion and Flame*, 191:527–540, 2018.

[75] J. E. Retter, R. A. Fontaine, J. B. Freund, N. G. Glumac, and G. S. Elliott. Coaxial DBD actuator design for control of a hydrogen diffusion flame. 54th AIAA Aerospace Sciences Meeting (SciTech 2016). AIAA Paper 2016-0199, Janurary 2016.

[76] Jonathan Retter, Gregory S. Elliott, and Sean P. Kearney. *Spatially correlated temperature, oxygen, and fuel measurements in a plasma-assisted hydrogen diffusion flame by one-dimensional fs/ps rotational CARS imaging.* American Institute of Aeronautics and Astronautics, 2017.

[77] A. Roettgen, I. Shkurenkov, M. Simeni Simeni, I. V. Adamovich, and W. R. Lempert. Time-resolved electron temperature and electron density measurements in a nanosecond pulse filament discharge in H2-He and $O_2$-He mixtures. *Plasma Sources Science and Technology*, 25:055008, 2016.

[78] A. Roettgen, I. Shkurenkov, M. Simeni Simeni, V. Petrishchev, I. V. Adamovich, and W. R. Lempert. Time-resolved electron density and electron temperature measurements in nanosecond pulse discharges in helium. *To appear Plasma Sources Science and Technology*, 25:055009, 2016.

[79] A. Roettgen, I. Shkurenkov, M. Simeni Simeni, V. Petrishchev, I. V. Adamovich, and W. R. Lempert. Time-resolved electron density and electron temperature measurements in nanosecond pulse discharges in helium. *Plasma Sources Science and Technology*, 25:055009, 2016.

[80] A. Roettgen, I. Shkurenkov, M. Simeni Simeni, V. Petrishchev, I. V. Adamovich, and W. R. Lempert. Time-resolved electron density and electron temperature measurements in nanosecond pulse discharges in helium. *Plasma Sources Science and Technology*, 25(5):055009, 2016.

[81] N. Sharan, C. Pantano, and D. J. Bodony. Time-stable overset grid method for hyperbolic problems using summation-by-parts operators. *Journal of Computational Physics*, 361:199–230, 2018.

[82] M. Simeni Simeni, E. Baratte, C. Zhang, K. Frederickson, I. Adamovich, H. Takana, and H. Nishiyama. Kinetic modeling of high-pressure surface ionization waves generated by ns pulse discharges. In Japan Sendai, editor, *17th International Symposium on Advanced Fluid Information*, pages 1–3, November 2017.

[83] M. Simeni Simeni, E. Baratte, C. Zhang, K. Frederickson, and I. V. Adamovich. Ps four-wave mixing measurements of electric field in nanosecond pulse discharges in ambient air, 2018.

[84] M. Simeni Simeni, B. M. Goldberg, C. Zhang, K. Frederickson, W. R. Lempert, and I. V. Adamovich. Electric field measurements in a nanosecond pulse discharge in atmospheric air. *Journal of Physics D: Applied Physics*, 50:184002, 2017.

[85] M. Simeni Simeni, B. M. Goldberg, C. Zhang, K. Frederickson, W. R. Lempert, and I. V. Adamovich. Electric field measurements in a quasi-two-dimensional ns pulse discharge in atmospheric air. 2017-th AIAA Aerospace Sciences Meeting (SciTech 2017), Grapevine, TX, 2017.

[86] M. Simeni Simeni, E. Baratte, Y.-C. Hung, K. Frederickson, and I. V. Adamovich. Ps four-wave mixing measurements of electric field in a ns pulse discharge in a hydrogen diffusion flame. *accepted Proceedings of the Combustion Institute*, 2018.

[87] M. Simeni Simeni, Y. Tang, Y.-C. Hung, K. Frederickson, and I. V. Adamovich. Electric field in ns pulse and ac electric discharges in a hydrogen diffusion flame. *accepted Combustion and Flame*, 2018.

[88] H. Takana, B. M. Goldberg, I. V. Adamovich, and H. Nishiyama. Numerical and experimental analyses of electric filed development in high pressure air nanosecond DBD. In *13th International Conference on Flow Dynamics*, pages 10–12, Japan, 2016. October Sendai.

[89] K. Tang, L. Massa, J. Wang, and J. B. Freund. A least-squares, adaptive uncertainty propagation approach for a plasma-coupled combustion system. GlobaCOMAS Congress 2016, VII European Congress on Computational Methods in Applied Sciences and Engineering, Greece, 2016.

[90] T. S. F. X. Teixeira, D. Padua, and W. Gropp. A DSL for performance orchestration. In *2017 26th International Conference on Parallel Architectures and Compilation Techniques (PACT)*, pages 372–372, Sept 2017.

[91] R. Vishnampet, D. B. Bodony, and J. B. Freund. A practical discrete-adjoint method for high-fidelity compressible turbulence simulations. *J. Comp. Phys.*, 285:173–192, 2015.

[92] Sam White and Laxmikant V. Kale. Optimizing point-to-point communication between adaptive mpi endpoints in shared memory. *Concurrency and Computation: Practice and Experience*, pages n/a–n/a.

[93] Sam White and Laxmikant V. Kale. Optimizing point-to-point communication between adaptive MPI endpoints in shared memory. In *The Workshop on Exascale MPI*, ExaMPI, 2017.

[94] C. Winters. *Laser Diagnostics of Reacting Molecular Plasmas for Plasma Assisted Combustion Applications*. PhD thesis, Ohio State University, 2017.

[95] C. Winters, Y. c. Hung, E. Jans, Z. Eckert, K. Frederickson, I. V. Adamovich, and oh N. Popov. Radical kinetics in hydrogen-air mixtures at the conditions of strong vibrational nonequilibrium. *Journal of Physics D: Applied Physics*, 50:505203, 2017.

[96] C. Winters, A. Chernukho, Z. Eckert, K. Frederickson, and I. V. Adamovich. Measurements of Ar* and OH number densities in a high-pressure nanosecond pulse discharge. AIAA Paper 2016-1211, January 2016.

[97] C. Winters, Z. Eckert, Z. Yin, K. Frederickson, and I. V Adamovich. Measurements and kinetic modeling of atomic species in fuel-oxidizer mixtures excited by a repetitive nanosecond pulse discharge. *Journal of Physics D: Applied Physics*, 51:015202, 2018.

[98] C. Winters, Z. Eckert, Z. Yin, K. Frederickson, and I. V Adamovich. Measurements and kinetic modeling of H and O atoms in fuel-oxidizer mixtures excited by a burst of nanosecond pulse discharge. AIAA Paper 2018-1194, 2018.

[99] C. Winters, Y.-C. Hung, E. Jans, K. Frederickson, and I. V. Adamovich. OH radical measurements in hydrogen-air mixtures at the conditions of strong vibrational nonequilibrium. AIAA Paper 2017-1584, 2017.

[100] C. Winters, V. Petrishchev, Z. Yin, W. R. Lempert, and I. V. Adamovich. Surface charge dynamics and OH and H number density distributions in near-surface nanosecond pulse discharges at a liquid / vapor interface. *Journal of Physics D: Applied Physics*, 48:424002, 2015.

[101] W. Zhang. Performance analysis and optimization of a CFD application. Master's thesis, University of Illinois at Urbana-Champaign, July 2015.

[102] W. Zhang, D. J. Bodony, J. L. Larson, and L. A. Wilson. ECSS experience: Performance of a CFD code running on Stampede's Intel Xeon Phi in symmetric mode. In *XSEDE 15*, St. Louis, MO, July 2015.

[103] W. Zhang, A. Lani, and M. Panesi. Analysis of non-equilibrium phenomena in inductively coupled plasma generators. *Physics of Plasmas*, 23(7), 2016.

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## Disclaimer