# Ozgur Tumuklu, Ph.D.

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googlescholar

## Work Experience

- **Rensselaer Polytechnic Institute (RPI)** **Troy, NY**
  *Assistant Professor in Mechanical, Aerospace, and Nuclear Engineering (MANE) Department* Aug. 2023 – Present
  - Principal Investigator in the Rensselaer Hypersonics Aerothermal Vehicle Analysis Lab (HAVA Lab) link.
  - Teaching Fluid Mechanics (MANE 2720) and Compressible Flows (MANE 6960)
  - HAVA implements high-fidelity numerical schemes for hypersonic turbulent flows.
  - HAVA develops high-fidelity modal stability approaches for hypersonic nonequilibrium flows.
  - HAVA model radiative rarefied flows.
  - HAVA models rarefied jet expansion flows for land and takeoff as part of the Artemis project.

- **University of Arizona (UoA)** **Tucson, AZ**
  *Postdoctoral Scholar in Aerospace and Mechanical Engineering Department* Jan. 2022 – Aug. 2023
  - Contributed to the validation of the Large Eddy Simulation (LES) and Detached Eddy Simulation(DES) turbulence models to the open-source software of Stanford University Unstructured NonEquilibrium MOdeling (SU2-NEMO) code for hypersonic flows along with Mutation++ library.
  - Responsible for hypersonic flows modeling for aero-optics applications using SU2-NEMO.
  - Contributed to the design and control of solid fuel ramjets (SFRJ) using the NASA Computer program CEA (Chemical Equilibrium with Applications).
  - Modeled hypersonic wake flows and their instabilities.
  - Responsible for reacting flows using high-fidelity chemical reactions.
  - High-fidelity ablation and combustion modeling using Porous material Analysis Toolbox based on OpenFoam (PATO).
  - Formulated mesh adaptation for hypersonic flow applications using AMGIO library.
  - Aided to thermal analysis for low-velocity flow applications for UoA optical sciences.
  - Taught undergraduate courses for more than 50 hours.
  - Mentored undergraduate and graduate students.

- **NASA Jet Propulsion Laboratory (JPL)** **Pasadena, CA**
  *JPL Postdoctoral Scholar in Analytical Chem. and Mat. Dev. Group* July. 2020 – Jan. 2022
  - Led to develop a parallel multispecies direct simulation Monte Carlo (DSMC)-JPL code from scratch and integration of high-fidelity collision and internal energy distribution models to model complex multispecies gas expanding flows.
  - Construction of Message-Passing Interface (MPI) communication topologies from and data-exchange algorithms to couple the DSMC-JPL code with an in-house finite-difference Navier-Stokes solver.
  - Modeling of 3-D expanding turbulent flows in a low-density flow environment with a LES and DSMC solver.
  - Implementation of wall models to a continuum solver to study supersonic jet impingement flows.
  - Numerical modeling of impinging jets and extensive validation and verification studies with the literature.

- **University of Illinois at Urbana-Champaign (UIUC)** **Urbana, IL**
  *Postdoctoral Research Associate* Nov. 2019 – June 2020
  - Modeling of high-density reacting flows using the DSMC method.
  - Modeling of high-fidelity chemical reactions and internal relaxations such as FHO-FR, bias, and QCT and implementation of these models to DSMC solvers.
  - Development and implementation of the collisional-radiative (CR) model to the spectral analysis software, NEQAIR.
  - Comparisons of the high-fidelity DSMC chemistry and relaxation models with the experiments being conducted in GALCIT T5 and HET facilities and continuum solvers.
  - Hypersonic reacting flows modeling using CFD for the wake of a cylinder and comparisons with DSMC.

- Simulations of high-density hypersonic reacting flows with open-source continuum solvers using OpenFOAM.

- **Momend Software Company** **Ankara, Turkey**
  *Software Engineer* Jan. 2019 – Nov 2020
  - Development of a semi-analytic heat conduction solver using C++.
  - Modeling of a ramjet engine inlet with a bleed section.

- **University of Illinois at Urbana-Champaign** **Urbana, IL**
  *Graduate Student* Aug. 2014 – Nov. 2018
  - Investigation of temporal characteristics of shock wave boundary layer interactions using kinetic approaches.
  - Led to the implementation of gas-phase and gas-surface chemical reactions to a DSMC code, SMILE.
  - Development and application of a particle-based ellipsoidal statistical Bhatnagar-Gross-Krook (BGK) method on shock-dominated hypersonic flows.
  - Developed data-driven methods from scratch for future state predictions and statistical noise reduction.
  - Contributed to an analysis of electric propulsion devices plumes under the effect of environmental species using novel computational approaches on several top supercomputers such as Topaz, Garnet, Thunder, Blue Waters.
  - Involved in the development of software called SUGAR, Scalable Unstructured Gas Dynamics with Adaptive Mesh Refinement.

- **Pennsylvania State University** **State College, PA**
  *Graduate Student* Aug. 2013 – July. 2013
  - Elimination of software bugs of the SMILE code and application of it on a 3D flows exploiting about 10,000 processors.
  - Parallelization of a DSMC code using OpenMP and MPI.

## Education

- **University of Illinois at Urbana-Champaign** **Urbana, IL**
  *Ph.D. in Aerospace Engineering* 2014 – 2018
- **Middle East Technical University** **Ankara, Turkey**
  *M.S.in Aerospace Engineering* 2010 – 2013
- **Middle East Technical University** **Ankara, Turkey**
  *B.S. Aerospace Engineering* 2007 – 2010
- **Middle East Technical University** **Ankara, Turkey**
  *B.S. in Physics (high-honor)* 2005 – 2009

## Computer Skills

- **Languages**: C/C++, Python, Fortran, Matlab.
- **Parallel Programming**: MPI (advanced), OpenMP, CUDA (beginner).
- **Computational Fluid Dynamic Frameworks**: SU2, OpenFOAM, MUTATION++,SPARTA SMILE, SUGAR, SU2, VORPAL, Palabos, Fenics, CANTERA, CEA, PATO, DATCOM (beginner).
- **Scripting**: Python, Bash.
- **Visualization** and I/O: VTK, ParaView, Tecplot, Gnuplot, Xmgrace, Blender.
- **Mesh Generation** GMSH (advance), Pointwise (intermediate).
- **Debugger**: DDT, TotalView.
- **Productivity**: Make, CMake, Git, Mendeley.
- **Documentation**: Latex, Beamer, Microsoft Office Tools.
- **Operating Systems**: Unix/Linux, Mac OS, Windows.

## Area of Interests

Aerodynamics, aerothermodynamics, rarefied gas dynamics, hypersonic flows, reacting flows, computational fluid dynamics (CFD), direct simulation Monte Carlo (DSMC) method, development and validation of software tools, open-source software, particle in cell method (PIC), turbulence, flow instabilities, multiphase flows, high-performance computing (HPC), artificial intelligence, combustion, control and guidance, space exploration, and space propulsion.

## Selected Awards and Funds

- NSF ACCESS Computational Award, 2024, (PI), 750K ACCESS Credits.
- NSF ACCESS Computational Award, 2024, (co-PI), 1.5M ACCESS Credits.
- New Horizon 2020 Marie Skłodowska-Curie Actions Cofund Award given to the top scientists in Europe.
- NSF Extreme Science and Engineering Discovery Environment Computational Allocation, 2020 (PI).
- Physics of Fluids Scilight Article (2018).
- Full scholarship during graduate programs.

## Journal Publications

- **Citations** = +477, **h-index** = 10, link
- **Tumuklu O.** and Hanquist K., 2023, Temporal characteristics of hypersonic flows over a double wedge with Reynolds number, (Editor's Pick) Physics of Fluids, Vol. 10 Issue doi.org/10.1063/5.0169648
- **Tumuklu O.**, Interaction of spanwise instabilities with shocks over a double cone (2024). (Completed, to be submitted to Theoretical and Computational Fluid Dynamics.)
- Sawant, S. S., **Tumuklu, O.,** Theofilis, V., & Levin, D. A. (2022). Linear instability of shock-dominated laminar hypersonic separated flows. In IUTAM Laminar-Turbulent Transition (pp. 651-660). Springer, Cham.
- Çetin, B., Kuşcu, Y. F., Çetin B., **Tumuklu, O.**, Cole, K. D., 2021, Semi-analytical source (SAS) method for 3-D transient heat conduction problems with moving heat source of arbitrary shape. International Journal of Heat and Mass Transfer, 165, 120692.
- **Tumuklu O.**, Levin, D.A., and Theofilis V., 2019, Modal analysis with Proper Orthogonal Decomposition of hypersonic separated flows over a double wedge, Physical Review Fluids 4.3: 033403 (Editors' Suggestion) doi.org/10.1103/PhysRevFluids.4.033403.
- **Tumuklu O.**, Levin, D.A., and Theofilis V., 2019, Kinetic modeling of unsteady hypersonic flows over a tick geometry, Physics of Fluids 31, 056108, doi:10.1063/1.5090341.
- **Tumuklu O.**, Theofilis V., and Levin D.A., 2018, On the unsteadiness of shock-laminar boundary layer interactions hypersonic flows over a double cone, Physics of Fluids 30, 106111 (Featured-Scilights Article) doi.org/10.1063/1.5047791.
- **Tumuklu O.**, Levin, D.A., and Theofilis V., 2018, Investigation of unsteady, hypersonic, laminar separated flows over a double cone geometry using a kinetic approach, Physics of Fluids 30.4: 046103 (Editor's Pick) doi.org/10.1063/1.5022598.
- **Tumuklu O.** and Levin, D.A., 2018, Particle simulations of the effects of atomic oxygen on ion thruster plumes, Journal of Spacecraft and Rockets, pp. 1-12 doi.org/10.2514/1.A34053.
- **Tumuklu, O.**, Li, Z., and Levin, D.A., 2016, Particle Ellipsoidal Statistical Bhatnagar-Gross-Krook Approach for Simulation of Hypersonic Shocks, AIAA Journal, pp.3701-3716
- Sawant, S., **Tumuklu, O.**, Jambunathan, R., and Levin, D.A., 2018, Application of Adaptively Refined Unstructured Grids in DSMC to Shock Wave Simulations, Computer and Fluids, 170, 197-212 doi.org/10.1016/j.compfluid.2018.04.026.
- Korkut, B., Levin, D.A. and **Tumuklu, O.**, 2017, Simulations of Ion Thruster Plumes in Ground Facilities Using Adaptive Mesh Refinement, Journal of Propulsion and Power, Vol.33, pp.681-696 doi.org/10.2514/1.B35958.
- Knight, D., Chazot, O., Austin, J., Badr, M. A., Candler, G., Celik, B.,..., Levin, D., **Tumuklu O.**, 2017, Assessment of predictive capabilities for aerodynamic heating in hypersonic flow, Progress in Aerospace Sciences, 90, 39-53 doi.org/10.1016/j.paerosci.2017.02.001.
- Sengil, N., **Tumuklu, O.** and Celenligil, M.C., 2016. A Monte Carlo-based Poisson's equation solver parallelized with Coarray Fortran. Turkish Journal of Electrical Engineering Computer Sciences, 24(5), pp.4545-4553 doi:10.3906/elk-

1402-60.

- Sengil, N., **Tumuklu, O.** and Celenligil, M.C., 2012. Implementation of a Monte Carlo method to a two-dimensional particle-in-cell solver using algebraic meshes. Nukleonika, 57, pp.313-316 doi.

## Conference Proceedings

- **Tumuklu, O.** 2024, Dynamics of Jet Expansion and Impingement Across a Spectrum of Nozzle Pressure Ratios, AIAA 2024-4086.
- **Tumuklu, O.** 2024, Effect of Spanwise Instabilities on Hypersonic Flows, AIAA 2024-3834.
- Pan S. **Tumuklu, O.** 2024, Composite Koopman Analysis of Hypersonic Nonequilibrium Flows Over a Double Wedge, AIAA 2024-4188.
- **Tumuklu, O.**, Hanquist, K.M., 2024, Hypersonic turbulence wake modeling from rarefied to continuum regimes. In AIP Conference Proceedings, Vol. 2996, No. 1. AIP Publishing, (Peer-reviewed).
- **Tumuklu, O.**, & Hanquist K.M., 2024, Characterization of Hypersonic Instabilities over a Double Cone, AIAA 2024-1481.
- Oveissi P., Goel A.,**Tumuklu, O.**, & Hanquist K.M., 2024, Adaptive Combustion Regulation in Solid Fuel Ramjet, AIAA 2024-0743.
- Liza M., **Tumuklu, O.**, & Hanquist K. M., 2024, Nonequilibrium Effects on Aero-Optics in Hypersonic Flows, AIAA 2023-3736.
- **Tumuklu, O.**, & Hanquist K.M., 2023 Unsteadiness of hypersonic flows over a double wedge, AIAA 2023-0860.
- Maier W., Needels J.T., Alonso J.J., Morgado F., Garbacz C., Fossati M.,**Tumuklu, O.**, & Hanquist K.M., 2023 Development of Physical and Numerical Nonequilibrium Modeling Capabilities within the SU2-NEMO Code, AIAA 2023-0860.
- **Tumuklu, O.**, & Bellan J., 2023, Development of a hybrid particle-continuum solver for studying plume expansion into rarefied flows, AIAA 2023-0073.
- Oveissi, P., Trivedi, A., Goel, A., **Tumuklu, O.**, Hanquist, K. M., Farahmandi, A., & Philbrick, D. (2023). Learning-based Adaptive Thrust Regulation of Solid Fuel Ramjet. AIAA 2023-2533).
- **Tumuklu, O.**, & Bellan J., 2022, Development and Validation Studies of a Multi-purpose DSMC Code, AIAA 2022-2017.
- **Tumuklu, O.**, Jouffray M., and Levin, D.A., 2021, Modeling of NO Emissions from a Hypersonic Ground-Based Facility, AIAA 2021-0105.
- **Tumuklu, O.**, Sawant S.S., Levin, D.A., Theofilis V., 2020. Analysis of unsteady hypersonic shock boundary layer interactions. In 60th Israel Annual Conference on Aerospace Sciences.
- Sawant S.S., **Tumuklu, O.**, Theofilis V., and Levin, D.A., 2020, Analysis of Spanwise Homogeneous Perturbations in Laminar Hypersonic Shock-Boundary Layer Interactions, AIAA 2020-0108.
- Sawant, S. S., **Tumuklu, O.**, Theofilis, V., & Levin, D. A., 2019. Study of Spanwise Perturbations in Hypersonic Shock-Wave/Boundary Layer Interactions on a Double Wedge. AIAA 2019-3442.
- **Tumuklu, O.**, Levin D. A., Theofilis V., 2019. Use of particle methods for understanding hypersonic shock boundary layer interactions. Appeared in AIP Conference Proceedings Vol. 2132, p. 090002 (2019) (Peer-reviewed).
- Sawant, S., **Tumuklu, O.**, Theofilis, V., & Levin, D. 2019. Disturbance Equations based on the Linearized BGK Model to Account for Thermal Nonequilibrium. In APS Division of Fluid Dynamics Meeting Abstracts (pp. M02-032).
- **Tumuklu, O.**, Levin, D.A., Theofilis, V., 2018, Development of New Techniques for Studying Unsteady Behavior in Hypersonic Boundary Layer Interactions. In 2018 Fluid Dynamics Conference (p. 3709) doi.org/10.2514/6.2018-3709.
- **Tumuklu, O.**, Levin, D.A., Theofilis, V., 2018, Effects of Reynolds Number on Laminar Boundary Layer Shock-Interaction Hypersonic Flows on a Double Cone. In 2018 Fluid Dynamics Conference (p. 4032) doi.org/10.2514/6.2018-4032.
- **Tumuklu, O.**, Levin, D.A., Theofilis, V., 2017, On the Temporal Evolution in Laminar Separated Boundary Layer Shock-Interaction Flows using DSMC In 55th AIAA Aerospace Sciences Meeting (p. 1614) doi.org/10.2514/6.2017-1614.
- **Tumuklu, O.**, Perez, J.M., Levin, D.A., Theofilis V., 2017. On Linear Stability Analyses of Hypersonic Laminar Separated Flows in a DSMC Framework Part I: Base Flow Computations in a Double Cone and a 'Tick' Model. In 57th Israel Annual Conference on Aerospace Sciences.
- **Tumuklu, O.**, Perez, J.M., Theofilis V., Levin, D.A., 2017. On Linear Stability Analyses of Hypersonic Laminar

Separated Flows in a DSMC Framework Part II: Residuals Algorithm and the Least Damped Global Modes. In 57th Israel Annual Conference on Aerospace Sciences.

- Sawant, S. S., **Tumuklu, O.**, and Levin, D. A., 2017. Novel use of AMR Unstructured Grids in DSMC Compressible Flow Simulations. In 47th AIAA Thermophysics Conference (p. 4028). doi.org/10.2514/6.2017-4028
- **Tumuklu, O.** and Levin, D.A., 2016. Simulation of Hypersonic Flows using a Particle-based Ellipsoidal Statistical Bhatnagar-Gross-Krook Method. In 54th AIAA Aerospace Sciences Meeting (p. 2060). doi.org/10.2514/6.2016-2060
- **Tumuklu, O.**, Levin, D.A., Gimelshein, S.F. and Austin, J.M., 2016. Modeling of near-continuum laminar boundary layer shocks using DSMC. AIP Conference Proceedings Vol. 1786, No. 1, p. 050004 (Peer-reviewed) doi.org/10.1063/1.4967554.
- **Tumuklu, O.**, Levin, D.A., Gimelshein, S.F. and Austin, J.M., 2016. Factors influencing flow steadiness in laminar boundary layer shock interactions. AIP Conference Proceedings Vol. 1786, No. 1, p. 050005.(Peer-reviewed) doi.org/10.1063/1.4967555.
- **Tumuklu, O.**, Levin, D.A. and Austin, J.M., 2015. Shock-shock interactions for a double wedge configuration in different gases. In 53rd AIAA Aerospace Sciences Meeting (p. 1520) doi.org/10.2514/6.2015-1520
- Sawant, S.S., Jambunathan, R., **Tumuklu, O.**, Korkut, B., Levin, D.A., 2016. Study of Shock-Shock Interactions Using an Unstructured AMR Octree DSMC Code. In 54th AIAA Aerospace Sciences Meeting (p.0501). doi.org/10.2514/6.2016-0501
- Sawant, S.S., Korkut, B., **Tumuklu, O.** and Levin, D.A., 2015. Development of an AMR octree DSMC approach for shock dominated flows. In 53rd AIAA Aerospace Sciences Meeting (p. 0070). doi.org/10.2514/6.2015-0070
- Patil, V.N., **Tumuklu, O.**, Li, Z. and Levin, D.A., 2014. Development of the Ellipsoidal Statistical Bhatnagar-Gross-Krook method for Hypersonic Flows. In 52nd Aerospace Sciences Meeting (p. 1211) doi.org/10.2514/6.2014-1211.

## Presentations and Seminars

- "Dynamics of Jet Expansion and Impingement Across a Spectrum of Nozzle Pressure Ratios", presented in 2024 AIAA Aviation Forum and Exposition , Las Vegas, NV.
- "Effect of Spanwise Instabilities on Hypersonic Flows", presented in 2024 AIAA Aviation Forum and Exposition , Las Vegas, NV.
- "Characterization of Hypersonic Instabilities over a Double Cone", presented in 2024 AIAA Science and Technology Forum and Exposition, Orlando, FL.
- Computational Modeling of Flows Bridging Continuum to Rarefied Regimes, invited seminar presented at *Rensselaer Polytechnic Institute*, Troy, NY (April, 2023 ).
- Unsteadiness of hypersonic flows over a double wedge in 2023 AIAA Science and Technology Forum and Exposition, National Harbor, MD.
- Development of a hybrid particle-continuum solver for studying plume expansion into rarefied flows in 2023 AIAA Science and Technology Forum and Exposition, National Harbor, MD.
- Hypersonic turbulence wake modeling from rarefied to continuum regimes in 32th International Symposium on Rarefied Gas Dynamics (2022), Seoul, Korea.
- Kinetic approaches for hypersonic flows, invited virtual seminar presented at *Florida State University*,Tallahassee , FL (Sep., 2021).
- Modeling of shock-boundary layer interactions and stability analysis using particle approaches, invited seminar presented at *Middle East Technical University*, Ankara, Turkey (Dec. 2018).
- Development of new techniques for studying unsteady behavior in hypersonic boundary layer interactions, in 2018 Fluid Dynamics Conference, Atlanta, GA.
- Effects of Reynolds number on laminar boundary layer shock-interaction hypersonic flows on a double cone, in 2018 Fluid Dynamics Conference, Atlanta, GA.
- On the temporal evolution in laminar separated boundary layer shock- interaction flows using DSMC, in *2017 AFOSR Meeting.* NASA-Langley.
- On the temporal evolution in laminar separated boundary layer shock-interaction flows using DSMC, in 2017 AIAA Science and Technology Forum and Exposition, Grapevine , TX.
- Simulation of hypersonic flows using a particle-based Ellipsoidal Statistical Bhatnagar-Gross-Krook method (ES-BGK), in 2016 AIAA Science and Technology Forum and Exposition, San Diego, CA.
- Factors influencing flow steadiness in laminar boundary layer shock interactions, in 30th International Symposium on

Rarefied Gas Dynamics, Victoria, BC, Canada

- Modeling of near-continuum laminar boundary layer shocks using DSMC, in 30th International Symposium on Rarefied Gas Dynamics, Victoria, BC, Canada
- Development of the ellipsoidal statistical Bhatnagar-Gross-Krook method for Hypersonic Flows, in 2014 AIAA Science and Technology Forum and Exposition, National Harbor, DC.
- A Monte Carlo-based Poisson's equation solver parallelized with Coarray Fortran, International Conference on Applied and Computational Mathematics, ICACM-2012, Ankara, Turkey.
- Implementation of a Monte Carlo method to a two-dimensional particle-in-cell solver using algebraic meshes, in International Conference on Research and Applications of Plasmas, Plasma-2011, Warsaw, Poland.