Peter Vorobieff Curriculum Vitæ¹

Work Address:

Department of Mechanical Engineering The University of New Mexico Albuquerque, NM 87131 Phone: (505) 277-8347 E-mail: kalmoth@unm.edu WWW: http://unm.edu/~kalmoth

Research • Fundamental hydrodynamic instabilities

Interests

- Meandering flows
- Multiphase flows
- Shock-accelerated flows
- Two-dimensional hydrodynamics
- Renewable energy
- Advanced flow field measurement techniques

EXPERIENCE

- 2016 ... Associate Chair and Director of Facilities, The University of New Mexico, Albuquerque, New Mexico. Supervised the departmental graduate program, directed facilities upgrades. Led award-winning undergraduate (J. Ludwigsen, 2019) and graduate (D. Freelong, 2019) research.
 2013 2016 Professor and Assistant Chair, The University of New Mexico, Albuquerque, New Mexico. Led award-winning graduate (N. Fathi, 2015) and undergraduate (D. Simons, 2016) research, organized successful faculty and staff hires.
- **2005 2012**Associate Professor, The University of New Mexico, Albuquerque, New Mexico.

Built novel tiltable shock tube. Led discovery of a new instability in shock-driven multiphase flow. Participated in conversion of Mechanical Engineering building into a smart building with active solar energy collection and thermal storage. Supervised award-winning graduate research (M. Anderson, 2012).

1999 – 2005 Assistant Professor, The University of New Mexico, Albuquerque, New Mexico.
 Built state-of-the-art experimental facilities and diagnostic systems. Su-

pervised award-winning undergraduate (D. Georgiev, J. Vigil, 2001) and graduate (A. Palekar, 2004, S. Gogte, 2005) research.

¹Date: 11-02-2020

1996 - 1999	Research Associate, Los Alamos National Laboratory, Los Alamos, New
	Mexico.
	Conducted experimental studies of fluid instabilities and turbulence.
	Developed first implementations of particle-image velocimetry (PIV) di-
	agnostic for shock-accelerated flows, for three-dimensional studies of tur-
	bulent rotating convection, and for flowing soap films. Supervised two
	graduate students.
1995 - 1996	Research Assistant, Lehigh University, Bethlehem, Pennsylvania.
	Conducted research in fluid mechanics in the areas of vortex dynamics,

- Conducted research in fluid mechanics in the areas of vortex dynamics, wakes, separated flows, visualization techniques. Developed software applications for numerically intensive experimental data processing and analysis. Proposed and implemented a new mathematical method of identification of topological features of fluid flows via wavelet filtering. Demonstrated a new energetically efficient technique of stall control on delta wings – intermittent trailing-edge blowing.
- **1992-1995 Teaching Assistant**, Lehigh University, Bethlehem, Pennsylvania. Conducted laboratory workshops, supervised undergraduate projects. Designed and programmed computer interface for a series of laboratory experiments in mechanical vibrations.
- 1991-1992 Interpreter/Programmer, Association of Space Explorers, Moscow, Russia. Developed code and computer graphics for an educational computer game

Developed code and computer graphics for an educational computer game and several computer videos, performed synchronous Russian/English translation.

1989-1991 Research Assistant, Institute for High Temperatures, Moscow, Russia. Conducted research in theoretical gas dynamics (laser propulsion). Developed code for numerical simulation programs. Performed the duties of UNIX system administrator.

EDUCATION

Lehigh University, Bethlehem, Pennsylvania. Ph.D. Mechanical Engineering, May 1996.

Research combining experimental fluid dynamics and applied mathematics. GPA 4.0. Dissertation: "Vortex breakdown on a maneuvering delta wing and related issues of flow analysis and topology."

M.V. Lomonosov Moscow State University, Moscow, Russia. M.S. Mechanical Engineering and Applied Mathematics, May 1989. Cum Laude.

Development of analytical methods applicable to a wide range of problems. GPA 4.0. Thesis: "On averaging parabolic equations."

SKILLS

	 Experience of designing, building and operating custom PIV (particle image velocimetry) velocity field acquisition and TLC (thermochromic liquid crystal) temperature visualization systems for experiments in gas and fluid dynamics. Expert knowledge of water tunnel, tow tank, wind tunnel and shock tube experimental system operation. Expert knowledge of PC hardware and software (Windows, Linux, OpenBSD, CygWin), and of UNIX workstations: SGI, IBM, Sun. C, C++, FORTRAN, Poco, HTML, XHTML, XML, Java, Javascript, Perl, Labview, Matlab, ETEX.
HONORS	
2019	Halliburton Professor.
2018	University of New Mexico School of Engineering Senior Faculty Research Excellence Award.
2016	University of New Mexico Golden Paw online teaching award.
2015	New Mexico Pi Sigma Professor of the Year.
2014	AIAA Associate Fellow.
2009	Best presentation award, Energy for the 21st Century conference, Los Alamos National Laboratory.
2001	 American Physical Society Gallery of Fluid Motion winner, APS-DFD 2001 Meeting. With K.P. Prestridge and others. Junior Faculty Research Excellence Award, School of Engineering,
	The University of New Mexico.
1999	Los Alamos National Laboratory DX Division Teamwork Award (with R.F. Benjamin, P.M. Rightley, and K.P. Prestridge).
1998	American Physical Society <i>Gallery of Fluid Motion</i> winner, APS-DFD 1998 Meeting. With D. Blair and I. Aronson.
1996	American Physical Society <i>Gallery of Fluid Motion</i> winner, APS-DFD 1996 Meeting. With P.M. Rightley and R.F. Benjamin.
1995	S.W. Kung Award for best graduate research, Lehigh University, Beth- lehem, Pennsylvania.
1992	Galactic Empire Award for best science fiction novel in Russian.
1989	Lomonosov scholarship, Moscow University.
1988	Chebyshev scholarship, Moscow University.
SERVICE	
	Associate editor, ASME Journal of Fluids Engineering, 2010-2016.
	Member of the Editorial Board, Transactions of the Wessex Institute, since 2014.
	Refereed for: AIAA Journal, Experiments in Fluids, International Journal of Imaging Systems and Technology, Journal of Fluid Mechanics, Journal of Fluids Engineering, Physical Review E, Physical Review Letters.

Membership: APS, ASME (NM student chapter advisor), AIAA (Associate Fellow), Pi Tau Sigma (NM Pi Sigma chapter coordinator).

Member, APS Committee on International Freedom of Scientists (2019-2021).

Organizer of the Nonlinear Phenomena and Dynamic Systems workshop, Apr. 30-May 2, 1998, Boulder, CO. Minisymposium chair at the 13th Canadian Symposium on Fluid Dynamics (CSFD), May 26-30, 1998, Vancouver, BC, Canada.

Session chair at the 1998, 2006, 2007, 2008 APS-DFD Meetings, 2012 AIAA ASM Meeting, 29th International Symposium on Shock Waves (ISSW29), 2013.

Organizing committee member, 6th International Conference on Computational and Experimental Methods in Multiphase and Complex Flow, 2011, Kos, Greece.

Organizer and chair, 7th International Conference on Computational and Experimental Methods in Multiphase and Complex Flow, 2013, A Coruña, Spain.

Organizer and chair, 8th International Conference on Computational and Experimental Methods in Multiphase and Complex Flow, 2015, Valencia, Spain.

Organizer and chair, 9th International Conference on Computational and Experimental Methods in Multiphase and Complex Flow, 2017, Tallinn, Estonia.

Organizer and chair, 10th International Conference on Computational and Experimental Methods in Multiphase and Complex Flow, 2019, Lisbon, Portugal.

Organizing committee member, 1st International Conference on Maritime Transport, 2019, Rome, Italy.

Organizing committee member, 13th International Conference on Advances in Fluid Mechanics, 1–3 September 2020, Prague, Czech Republic (held online).

Service within department

1999-2001Computer committee member2000-2006webmaster-at-large2001-2005Computer committee chair2003Faculty search committee2004-2010Steering committee member2005-2007Lab committee chair2009Faculty search committee

2012-2015	Leadership committee member
2014	Staff search committee
2015	Faculty search committee
2016	Staff search committee
2018	Faculty search committee
2019	Faculty search committee

Service within university

2003-2005	KUNM board member
2010-2013	Faculty Ethics Committee member
2011-2012	Research Allocations Committee member
2012-2013	Research Allocations Committee chair
2014-2016	Research Policy Committee member
2014-2016	Information Tecnology (IT) use committee member
2016-2019	Chemical and Laboratory Safety committee member
2016	UNM School of Engineering Academic Council member
2016	UNM School of Engineering Ranking and Reputation Committee member

Graduate Jonathan Gallegos, M.S. (2001), Experimental Studies of the onset of Bé-Students nard - von Kármán instability.

Nagoor-Gani Mohamed, M.S. (2003), Quantitative Analysis of Disorder Growth in Transition to Turbulence.

Tanveer Shakeel, M.S. (2003), Far wake interactions behind a pair of cylinders, **Ph.D. (2006)**, Experimental study of turbulence using soap film tunnel.

Chris Platero, M.S. (2003, co-advised with C.R. Truman), Fractal dimension evolution in a shear layer instability.

Kathy Meyer, M.S. (2003, co-advised with C.R. Truman), *Planar Laser Induced Fluorescence (PLIF): Low Pressure Investigations.*

Salil Gogte, M.S. (2005), Flow measurements near superhydrophobic surfaces.

Richard Truesdell, **Ph.D. (2006, co-advised with A.A. Mammoli)**, Modification of the no-slip boundary condition by superhydrophobic wall patterning. Charlie Booker, M.S. (2006), Destruction of the second wake. Aparna Korlimarla, M.S. (2006), Evolution of a quasi-2D shear layer in a soap-film flow.

Greg Orlicz, M.S. (2007), Shock driven instabilities in a varicose, heavygas curtain : Mach number effects, **Ph.D. (2012)**, A Mach number study of shock-accelerated heavy gas curtain.

Daniel Coughlin, M.S. (2008), Real-time detection of biological threat agents in a cloud.

Evan Johnson, M.S. (2009), Planar and oblique shock wave interaction with a droplet seeded gas cylinder.

Michael Anderson, Ph.D. (2011), Experimental and numerical investigation of shock interaction with multiphase media.

Joseph Conroy, M.S. (2012), Experimental studies of particle-lag instability.

Ross White, M.S. (2012), Planar and oblique shock interaction with gas and particle-seeded cylinders.

Nima Fathi, M.S. (2012), Particle trajectories in low Reynolds number linear shear flow, **Ph.D. (2017)**, Evaluation and enhancement of clean energy systems: analytical, computational and experimental study of solar and nuclear cycles.

Clinton Corbin, M.S. (2014, co-advised with C.R. Truman), UNM Shock Tube Modernization.

Tennille Bernard, M.S. (2014, co-advised with C.R. Truman), Observation and Measurement of Instabilities due to Shock Focusing.

Garrett Kuehner, M.S. (2014, co-advised with C.R. Truman), Behavior of the Embedded Phase in a Shock-Driven Two-Phase Flow.

Lin Zheng, M.S. (2014), A 3D Computational Fluid Dynamics Model Validation for Candidate Molybdenum-99 Target Geometry.

Jianwei Ju, Ph.D. (2014), Effective colloidal particle properties from molecular dynamics simulations.

Gregory Naranjo, M.S. (2015), Development and analysis of a convergingdiverging nozzle laboratory apparatus.

Alfred Flores, M.S. (2015), Design and fabrication of a flexible apparatus for a low Reynolds number particle interaction flow.

Patrick Wayne, M.S. (2015), Analysis of Kelvin-Helmholtz instabilities developing from oblique shock interaction with a heavy gas column, **Ph.D.** (2019), Characterization of single- and multi-phase shock-accelerated

flows.

Andrew Williams, **Ph.D.** (2016), Effect of slip boundary condition in laminar flow on heat transfer using microtextured, superhydrophobic surfaces.

Wendy Flores, M.S. (2020), *Emissivity measurements of painted and aerosol-deposited thermographic phosphors (YAG:DY and MFG:MN)*.

Caleb White, M.S. (2020), Qualitative investigation of gaseous hydrodynamic mixing model efficacy and associated sensitivity. Patents
US Patent 7,416,903, "Wavy Interface Mixer," L.A. Sklar, A.A. Mammoli, R.A. Truesdell, P. Vorobieff, 2008.
US Patent 8,567,259, "Optical Phase Shift Fluid Flow Velocity Measurement Mechanism," G. Ballard, P. Vorobieff, 2013.
US Patent 10,006,443, "Inflatable, Free-Standing Solar Updraft Tower with Optimal Geometry and Active Control," P. Vorobieff, N. Fathi, A. Mammoli, V. Putkaradze, M. Chi, S. Aleyasin, F. Gay-Balmaz, 2018.
Provisional Application No. 62/775,294, "Multi-Source Sustainable-Renewable Energy Harvester," P. Vorobieff, N. Fathi, S. Aleyasin, P. Mc-Daniel, filed Dec. 4, 2018.

PUBLICATIONS (technical only)¹

Total number of citations (including references to Ph.D. dissertation and conference papers and abstracts): about 2,770, h-index 28.

Books Edited

- C.A. Brebbia, P. Vorobieff (eds.), "Computational Methods in Multiphase Flow VII," in series WIT Transactions on Engineering Sciences, WIT Press, Southhampton, UK (2013), ISBN: 9781845647346, 360 pp.
- P. Vorobieff, C.A. Brebbia (eds.), "Computational Methods in Multiphase Flow VIII," in series WIT Transactions on Engineering Sciences, WIT Press, Southhampton, UK (2015), ISBN: 9781845649463, 620 pp.
- P. Vorobieff, C.A. Brebbia (eds.), "Computational & Experimental Methods in Multiphase & Complex Flow IX," in series WIT Transactions on Engineering Sciences, WIT Press, Southhampton, UK (2017), ISBN: 9781784661953, 276 pp.
- 4. P. Vorobieff, C.A. Brebbia (eds.), "Multiphase Flow: Theory and Applications," WIT Press, Southhampton, UK (2018), ISBN: 9781784663117, 466 pp.
- S. Hernandez, P. Vorobieff (eds.), "Computational & Experimental Methods in Multiphase & Complex Flow X," in series WIT Transactions on Engineering Sciences, Vol. 123, WIT Press, Southhampton, UK (2019), ISBN: 9781784663292, 250 pp.
- 6. S. Hernandez, P. Vorobieff (eds.), "Multiphase Flow: Computational & Experimental Methods," WIT Press, Southhampton, UK (2020), ISBN: 9781784664176, 136 pp.

Review Papers

1. P. Vorobieff, S. Kumar, "Experimental studies of Richtmyer-Meshkov instability," *Recent Research Developments in Fluid Dynamics* Vol. 5 (2004), pp. 33-55 [8].

Book contributions

- I. Aranson, D. Blair, and P. Vorobieff, "Interface motion in a vibrated granular layer²," in A gallery of fluid motion, ed. M. Samimy, Cambridge University Press, 2003, p. 55.
- P.M. Rightley, P. Vorobieff, and R.F. Benjamin, "Mushrooms and snakes: a visualization of Richtmyer-Meshkov instability³," in *A gallery of fluid motion*, ed. M. Samimy, Cambridge University Press, 2003, p. 93.

¹Numbers in square brackets indicate number of times cited (according to ISI Citation index or Google Scholar Citation index), if known. In this section, publications are first organized by type (review papers, book contributions, research papers), then by journal, in descending order of journal 5-year impact factor (as indicated in round brackets after journal name). Names of UNM student authors are underlined, * indicates undergraduate and ** – graduate student authors.

²This contribution is a revised version of an entry originally published in Physics of Fluids.

³This contribution is a revised version of an entry originally published in Physics of Fluids.

Reviewed Journals and Proceedings

Nature (41.6)

 <u>K. Mertens</u>^{**}, V. Putkaradze, and P. Vorobieff, "Braiding patterns on an inclined plane," *Nature* Vol. 430, No. 6996 (2004), p. 165 [24].

Science Advances (13.1)

P. Wayne^{**}, S. Cooper^{*}, D. Simons^{*}, I. Trueba-Monje^{*}, D. Freelong^{**}, G. Vigil^{*}, C. R. Truman, V. Vorob'ev, T. Clark, and P. Vorobieff, "Dalton's and Amagat's laws fail in gas mixtures with shock propagation," *Science Advances* (2019), Vol. 5 No. 12, art. no. eaax4749.

Physical Review Letters (8.9)

- M.K Rivera, P. Vorobieff, and R.E. Ecke, "Turbulence in Flowing Soap Films: Velocity, Vorticity and Thickness Fields," *Physical Review Letters* Vol. 81 No. 7 (1998), pp. 1417-1420 [136].
- 7. P. Vorobieff, P.M. Rightley, and R.F. Benjamin, "Power-law Spectra of Incipient Gas-Curtain Turbulence," *Physical Review Letters* Vol. 81 No. 11 (1998), pp. 2240-2243 [27].
- K.P. Prestridge, P.M. Rightley, P. Vorobieff, and R.F. Benjamin, "Validation of an Instability Growth Model Using PIV Measurements," *Physical Review Letters* Vol. 84 No. 19 (2000), pp. 4353-4356 [53].
- E. Ben-Naim, Z.A. Daya, P. Vorobieff, and R.E. Ecke, "Knots and random walks in vibrated granular chains," *Physical Review Letters* Vol. 86 No. 8 (2001), pp. 1414-1417 [101].
- <u>R. Truesdell</u>^{**}, A. Mammoli, P. Vorobieff, F van Swol, and C.J. Brinker, "Drag reduction on a patterned superhydrophobic surface," *Physical Review Letters* Vol. 97 No. 4 (2006), art. no. 044504 [282].
- V. Putkaradze and P. Vorobieff, "Instabilities, Bifurcations, and Multiple Solutions in Expanding Channel Flows," *Physical Review Letters* Vol. 97 No. 14 (2006), art. no. 144502 [13].
- B. Birnir, K. Mertens, V. Putkaradze, and P. Vorobieff, "Meandering fluid streams in the presence of flow rate fluctuations," *Physical Review Letters* Vol. 101 No. 11 (2008), art. no. 114501 [28].
- P. Vorobieff, <u>M. Anderson</u>^{**}, <u>J. Conroy</u>^{**}, <u>R. White</u>^{**}, C.R. Truman, and S. Kumar, "Vortex formation in a shock-accelerated gas induced by particle seeding," *Physical Review Letters* Vol. 106 (2011), art. no. 184503 [48].

Journal of Cleaner Production (5.7)

 N. Fathi, P. McDaniel, S. S. Aleyasin, M. Robinson, P. Vorobieff, S. Rodriguez, and C. deOliveira, "Efficiency enhancement of solar chimney power plant by use of waste heat from nuclear power plant," *Journal of Cleaner Production Vol.* 180 (2018), pp. 407-416 [9].

Solar Energy (4.0)

- <u>C. Armenta</u>^{**}, P. Vorobieff, and A. Mammoli, "Summer off-peak performance enhancement for rows of fixed solar thermal collectors using flat reflective surfaces," *Solar Energy* Vol. 85 no. 9 (2011), pp. 2041-2052 [13].
- V. Putkaradze, P. Vorobieff, A. Mammoli, and <u>N. Fathi</u>^{**}, "Inflatable free-standing solar towers," *Solar Energy* Vol. 98 (A) (2013), pp. 85-98 [28].

Energy and Buildings (3.0)

- <u>M. Ortiz</u>^{**}, H. Barsun, <u>H. He</u>^{**}, P. Vorobieff, and A. Mammoli, "Modeling of a solarassisted HVAC system with thermal storage," *Energy and Buildings* Vol. 42, No. 4 (2010), pp. 500-509 [94].
- A. Mammoli, P. Vorobieff, H. Barsun, R. Burnett, and <u>D. Fisher</u>^{**}, "Energetic, economic and environmental performance of a solar-thermal-assisted HVAC system," *Energy and Buildings* Vol. 42, No. 9 (2010), pp. 1524-1535 [84].

Journal of Rheology (3.0)

M.S. Ingber, A.A. Mammoli, P. Vorobieff, <u>T. McCollam</u>^{**}, and A.L. Graham, "Experimental and numerical analysis of irreversibilities among particles suspended in a Couette device," *Journal of Rheology* Vol. 50 (2006), pp. 99-114 [17].

Journal of Fluid Mechanics (2.9)

- P. Vorobieff and R.E. Ecke, "Turbulent Rotating Convection: an Experimental Study," Journal of Fluid Mechanics Vol. 458 (2002), pp. 191-218 [81].
- <u>K. Mertens</u>^{**}, V. Putkaradze, and P. Vorobieff, "Morphology of a stream flowing down an inclined plane. Part 1. Braiding," *Journal of Fluid Mechanics* Vol. 531 (2005), pp. 49-58 [38].
- B. Birnir, K. Mertens, V. Putkaradze, and P. Vorobieff, "Morphology of a stream flowing down an inclined plane. Part 2: Meandering," *Journal of Fluid Mechanics* Vol. 607 (2008), pp. 401-411 [25].

Applied Thermal Engineering (2.7)

 J. Carlson, D. Menicucci, P. Vorobieff, A. Mammoli, and H. He, "Infrared imaging method for flyby assessment of solar thermal panel operation in field settings," *Applied Thermal Engineering* Vol. 70 No. 1 (2014), pp. 163-171 [8]. N. Fathi^{**}, S.S. Aleyasin, and P. Vorobieff, "Numerical-Analytical Assessment on Manzanares Prototype," *Applied Thermal Engineering* Vol. 102 No. 5 (2016), pp. 243–250 [15].

Physical Review Fluids (2.5)

 N. Fathi, K. Mertens, V. Putkaradze, and P. Vorobieff, "Shock-driven transition to turbulence: Emergence of power-law scaling," *Physical Review Fluids* Vol. 2 No. 5 (2017), art. no. 052601 [1].

Physical Review E (2.3)

- P. Vorobieff and R.E. Ecke, "Cylinder Wakes in Flowing Soap Films," *Physical Review E* Vol. 60 No. 3 (1999), pp. 2953-2956 [39].
- <u>R.A. Truesdell</u>^{**}, P.V. Vorobieff, L.A. Sklar, and A.A. Mammoli, "Mixing of a continuous flow of two fluids due to unsteady flow," *Physical Review E* Vol. 67, No. 6 (2003), art. no. 066304 [28].
- P. Vorobieff, <u>N.-G. Mohamed</u>^{**}, C. Tomkins, C. Goodenough, M. Marr-Lyon, and R.F. Benjamin, "Scaling evolution in shock-induced transition to turbulence," *Physical Review E* Vol. 68, No. 6 (2003), art. no. 065301 [34].
- 29. M. Popova, P. Vorobieff, M.S. Ingber, and A.L. Graham, "Interaction of two particles in a shear flow," *Physical Review E* Vol. 75 no. 6 (2007), art. no 66309 [12].

 $Europhysics \ Letters \ (2.3)$

30. N. Fathi, K. Mertens, V. Putkaradze, and P. Vorobieff, "Comment on 'The role of wetting heterogeneities in the meandering instability of a partial wetting rivulet' by Couvreur S. and Daerr A.," *Europhysics Letters* Vol. 108 No. 5 (2014), art. no. 54002 [1].

Physics of Fluids (2.3)

- J.-C. Lin, P. Vorobieff, and D.O. Rockwell, "Space-Time Imaging of a Turbulent Near-Wake by High-Image-Density Particle Image Cinematography," *Physics of Fluids* Vol. 8 No. 2 (1996), pp. 555-564 [29].
- P.M Rightley, P. Vorobieff, and R.F. Benjamin, "Evolution of a Shock-Accelerated Thin Fluid Layer," *Physics of Fluids* Vol. 9 No. 6 (1997), pp. 1770-1782 [82].
- P.M. Rightley, P. Vorobieff, and R.F. Benjamin, "Mushrooms+Snakes: an investigation of Richtmyer-Meshkov instability," *Physics of Fluids* Vol. 9 No. 9 (1997), Special Section p. S6 [3].
- P. Vorobieff and R.E. Ecke, "Transient States During Spin-Up of a Rayleigh-Bénard Cell," *Physics of Fluids* Vol. 10 No. 10 (1998), pp. 2525-2538 [8].

- P.M. Rightley, P.Vorobieff, R. Martin, and R.F. Benjamin, "Experimental Observations of the Mixing Transition in a Shock-Accelerated Gas Curtain," *Physics of Fluids* Vol. 11 No. 1 (1999), pp. 186-209 [84].
- P. Vorobieff, M.K. Rivera, and R.E. Ecke, "Soap Film Flows: Statistics of Two-Dimensional Turbulence," *Physics of Fluids* Vol. 11 No. 8 (1999), pp. 2167-2177 [67].
- I. Aranson, D. Blair, and P. Vorobieff, "Interface Nucleation in Vibrating Granular Media," *Physics of Fluids* Vol. 11 No. 9 (1999), p. S9 [2].
- K.P. Prestridge, C. Tomkins, P. Rightley, P. Vorobieff, and R.F. Benjamin, "The Courtship and Mating Rituals of Vortices," *Physics of Fluids*, Vol. 14 No. 9 (2002), p. S10.
- 39. P. Vorobieff, <u>D. Georgiev</u>^{*}, and M.S. Ingber, "Onset of the second wake: Dependence on the Reynolds number," *Physics of Fluids*, Vol. 14 No. 7 (2002), pp. L53-L56 [17].
- 40. C. Tomkins, K. Prestridge, P. Rightley, M. Marr-Lyon, P. Vorobieff, and R.F. Benjamin, "A quantitative study of the interaction of two Richtmyer-Meshkov unstable gas cylinders," *Physics of Fluids* Vol. 15 No. 4 (2003), pp. 986-1004 [58].
- 41. <u>S. Gogte</u>^{**}, P. Vorobieff, <u>R. Truesdell</u>^{**}, A. Mammoli, F. van Swol, P. Shah, and C.J. Brinker, "Effective slip on textured superhydrophobic surfaces," *Physics of Fluids* Vol. 17 (2005), art. no. 051701 [244].
- 42. S. Kumar, <u>G. Orlicz</u>^{**}, C. Tomkins, C. Goodenough, K. Prestridge, P. Vorobieff, and R. Benjamin, "Stretching of material lines in shock-accelerated gaseous flows," *Physics of Fluids* Vol. 17 (2005), art. no. 082107 [56].
- 43. G. Orlicz, S. Balasubramanian, P. Vorobieff, and K. Prestridge. "Mixing transition in a shocked variable-density flow," *Physics of Fluids* Vol. 27 No. 11 (2015), art. no. 114102 [12].

Proceedings of the Royal Society A (2.1)

44. M. Chi, F. Gay-Balmaz, V. Putkaradze, and P. Vorobieff, "Dynamics and optimal control of flexible solar updraft towers," *Proceedings of the Royal Society A: Mathematical, Physical, and Engineering Sciences* Vol. 471 (2015), art. no. 20140539 [5].

Journal of Fluids Engineering (2.1)

- 45. P. Vorobieff and R.E. Ecke, "Flow Structure in a Rayleigh-Bénard cell upon impulsive spin-up," *Journal of Fluids Engineering* Vol. 120 (1998), pp. 672-675.
- 46. <u>P. Wayne</u>^{**}, P. Vorobieff, H. Smyth, <u>T. Bernard</u>^{**}, <u>C. Corbin</u>^{**}, A. Maloney, <u>J. Conroy</u>^{**}, <u>R. White</u>, M. Anderson, S. Kumar, C.R. Truman, and D. Srivastava, "Shock-driven particle transport off smooth and rough surfaces," *ASME Journal of Fluids Engineering* Vol. 135 No. 6 (2013), art. no. 061302 [6].

- 47. <u>T. Bernard</u>^{**}, C.R. Truman, P. Vorobieff, <u>C. Corbin</u>^{**}, <u>P.J. Wayne</u>^{**}, <u>G. Kuehner</u>^{**}, M. Anderson, and S. Kumar, "Observation of the Development of Secondary Features in a Richtmyer–Meshkov Instability Driven Flow," *Journal of Fluids Engineering* Vol. 137 No. 1 (2015), art. no. 011206 [10].
- S.S. Aleyasin, <u>N. Fathi</u>^{**}, and P. Vorobieff, "Experimental Study of the Type VI Stilling Basin Performance," *Journal of Fluids Engineering* Vol. 137 No. 3 (2015), pp. 034503-1– 034503-9 [1].
- 49. S. S. Aleyasin, N. Fathi, M. F. Tachie, P. Vorobieff, and M. Koupriyanov, "On the development of incompressible round and equilateral triangular jets due to Reynolds number variation," *Journal of Fluids Engineering* Vol. 140 No. 11 (2018), art. no. 111202 [6].
- 50. J. A. Sward^{**}, P. C. Scott^{*}, P. J. Wayne^{**}, N. Jackson, P. Vorobieff, R. Lumia, and S. V. Poroseva, "Harvesting Energy From an Ionic Polymer–Metal Composite in a Steady Air Flow," *Journal of Fluids Engineering* Vol. 142 No. 8 (2020), art. no. 081204.
- Physica D Nonlinear Phenomena (2.0)
 - 51. P. Vorobieff and R.E. Ecke, "Vortex Structure in Rotating Rayleigh-Bénard Convection," *Physica D* (Amsterdam) Vol. 123 (1998), pp. 153-160 [30].
 - P. Vorobieff, P.M. Rightley, and R.F. Benjamin, "Shock-driven Gas Curtain: Fractal Dimension Evolution in Transition to Turbulence," *Physica D* (Amsterdam) Vol. 133, pp. 469-476 (1999) [29].
 - 53. S. Kumar, P. Vorobieff, <u>G. Orlicz</u>^{**}, <u>A. Palekar</u>^{**}, C. Tomkins, C. Goodenough, M. Marr-Lyon, K.P. Prestridge, and R.F. Benjamin, "Complex flow morphologies in shock-accelerated gaseous flows," *Physica D* (Amsterdam) Vol. 235 no. 1-2 (2007), pp. 21–28 [31].

Experiments in Fluids (1.8)

- K.P. Prestridge, P.M. Rightley, P. Vorobieff, N.A. Kurnit, and R.F. Benjamin, "Simultaneous Density-Field Visualization and PIV of a Shock-Accelerated Gas Curtain," *Experiments in Fluids* Vol. 29 No. 4 (2000), pp. 339-346 [45].
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Reports

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- 129. P. Vorobieff, C.R. Truman, and <u>J. Gallegos^{**}</u>, "PIV diagnostics for flow control applications," *Proceedings of 2000 Contractors' Meeting in Turbulence and Rotating Flows*, Air Force Office of Scientific Research, Arlington, VA, pp. 285-289.
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- 139. W. Flores-Brito, P. Vorobieff, J. T. Mahaffey, A. Vackel, and K. N. G. Hoffmeister, "Emissivity measurements of YAG:Dy and MgFGeO:Mn," SAND2019-10537C, Sandia National Laboratories report (2019), 9 pp.

Invited presentations

- "Kraichnan was right! 2D turbulence," poster presentation. Presented at the *Turbulence:* Challenges for the 21st Century conference, May 18-21, 1998, Los Alamos, New Mexico. With R.E. Ecke.
- 2. "Phenomenology and statistics of 2D turbulence," presented at the 13th Canadian Symposium on Fluid Dynamics (CSFD), May 26-30, 1998, Vancouver, Canada.
- 3. "Fluid instabilities and turbulence: some experimental results," presented at the seminar of the Mechanical Engineering Department, University of New Mexico, Sep. 15, 1998, Albuquerque, New Mexico.
- "Fluid instability and turbulence studies via PIV," presented at the seminar of the Department of Theoretical and Applied Mechanics, University of Illinois, Sep. 24, 1998, Urbana, Illinois.
- 5. "Experiments in fluid turbulence," presented at the University of California, San Diego Physics Seminar, Jan. 18, 1999, San Diego, California.
- 6. "Interface motion in a vibrated granular layer," video presentation. Presented at the Centennial Meeting of the American Physical Society, March 20-26, 1999, Atlanta, Georgia. With D. Blair and I. Aronson.
- "Dynamics of shock-accelerated density interfaces," presented at the Dynamics of Interfaces, Patterns and Domains '99 International Workshop, April 22-24, 1999, Los Alamos, New Mexico.
- 8. "Wakes in soap films," presented at the 5th Experimental Chaos Conference, June 28-July 1, 1999, Orlando, Florida.
- 9. "Experiments in nonlinear science," presented at Santa Fe Institute with R.E. Ecke, 1999, 2000.
- 10. "Quasi-two-dimensional studies in gravity-driven soap films," presented at Eötvös University (Physics Department) Graduate Student Seminar, Budapest, Hungary, June 2001.
- "Bluff-body wake evolution and interaction in 2D," presented at the 4th International conference on Advances in Fluid Mechanics (AFM2002), Ghent, Belgium, May 14-17, 2002. With D. Georgiev* and <u>T. Shakeel</u>*.

- "Experimental studies of shock-driven instabilities," presented at the Washington University in St. Loius (MAE Department) Graduate Student Seminar, St. Louis, Missouri, USA, Oct. 30, 2003.
- 13. "Experiments in impulsively-driven instabilities," presented at the Fluid Mechanics Series seminar, California Institute of Technology, Pasadena, California, USA, Apr. 23, 2004.
- 14. "Shock-driven transition to turbulence: curiouser and curiouser," presented at the Special Session on Mathematical Methods in Turbulence, Fall Western Section Meeting of the American Mathematical Society, Albuquerque, New Mexico, USA, Oct. 17, 2004.
- 15. "Richtmyer-Meshkov instability," presented at the University of Victoria, Victoria, British Columbia, Canada, June 30, 2006.
- 16. "Irreversibility and chaos in shear flow carrying particles," presented at the 2007 Spring Western Section Meeting of the American Mathematical Society, Special Session on Subjects in and Around Fluid Dynamics, Tucson, Arizona, USA, Apr. 22, 2007.
- 17. "Turbulence in two, three, and one dimension," presented at the Institute for High Temperatures, Russian Academy of Sciences, Moscow, Russia, June 21, 2007,
- "Turbulence and spatial dimensionality," keynote presentation at Russian Low-Temperature Plasma Conference, St. Petersburg – Petrozavodsk, Russia, June 26, 2007.
- "Quasi-two-dimensional turbulent decay and fossil turbulence," presented at the Fall Western Section Meeting of the American Mathematical Society, Special Session on Recent Developments in 2-D Turbulence, Albuquerque, New Mexico, USA, Oct. 13, 2007.
- 20. "Analogues of Rayleigh-Taylor and Richtmyer-Meshkov instabilities in flows with nonuniform particle and droplet seeding," presented at the Sixth International Conference on Computational and Experimental Methods in Multiphase and Complex Flow, Kos, Greece, June 15, 2011.
- 21. "Analogues of Rayleigh-Taylor and Richtmyer-Meshkov instabilities in gas and plasma with inclusions," presented at the Russian Low-Temperature Plasma Conference, Petroza-vodsk, Russia, June 23, 2011.
- 22. "Vortex deposition and transition to turbulence in a shock-accelerated gas with particle/droplet seeding," presented at the 17th Biennial International Conference of the APS Topical Group on Shock Compression of Condensed Matter (APS-SCCM), June 26 – July 1 2011, Chicago, Illinois. With <u>J. Conroy</u>^{**}, <u>M. Anderson</u>^{**}, <u>R. White</u>^{**}, C.R. Truman, and S. Kumar.
- 23. "Particle lag instability," presented at the 2011 Fall Western Section Meeting of the American Mathematical Society, University of Utah, Salt Lake City, UT, October 22-23, 2011. With <u>M. Anderson</u>^{**}, J. Conroy^{**}, <u>R. White</u>^{**}, P. Wayne^{*}, C.R. Truman, and S. Kumar.

- 24. "Optimal design of an inflatable, free-standing solar updraft tower," presented at the 2013 Spring Western Section Meeting of the American Mathematical Society, University of Colorado–Boulder, Boulder, CO, April 13-14, 2013. With A.A. Mammoli, V.P. Putkaradze, and <u>N. Fathi</u>**.
- 25. "Shock-driven instability in multiphase flow," presented at San Diego State University Aerospace Engineering Department, May 3, 2013.
- 26. "Morphology of shock-accelerated multiphase flow: experiment and modeling," presented at the 7th International Conference onc Computational and Experimental Methods in Multiphase and Complex Flow, A Coruña, Spain July 3-5, 2013. With M. Anderson, J. Conroy, C.R. Truman, and S. Kumar.
- 27. "Particle-lag instability and other oddities in shock-driven multiphase flow," presented at the Center for Nonlinear Studies, Los Alamos National Laboratory, Los Alamos, New Mexico, March 12, 2014.
- 28. "Новая неустойчивость за ударной волной в многофазных потоках (New Shock-Driven Instability in Multiphase Flows)," presented at V.V. Fortov (President of the Russian Academy of Sciences) OIVT Seminar, Moscow, Russia, April 10, 2014.
- 29. "Richtmyer-Meshkov and other instabilities in compressible multiphase flow," presented at the 8th International Conference on Computational and Experimental Methods in Multiphase and Complex Flow, Valencia, Spain, April 20-22, 2015. With P. Wayne, D. Olmstead, C.R. Truman, and S. Kumar.
- 30. "Control of a flexible chimney under wind loading," presented at the Special Session on Inverse Problems, AMS Spring Western Sectional Meeting, University of Utah, Salt Lake City, UT, April 9-10, 2016. With M. Chi, F. Gay-Balmaz, V. Putkaradze, and N. Fathi.
- 31. "Flow pattern alteration near a hydrofoil due to effective slip: an experimental study," presented at the 11th International Conference on Advances in Fluid Mechanics, Ancona, Italy, September 5-7, 2016. With S. Gogte and A. Mammoli.
- 32. "Flexible solar updraft towers: stability and control," presented at the Special Session on Contemporary Geometric Methods in Mechanics and Control, AMS Fall Southeastern Sectional Meeting, North Carolina State University, Raleigh, NC, November 12-13, 2016. With M. Chi, F. Gay-Balmaz, V. Putkaradze, and N. Fathi.
- 33. "Instabilities in a shock interaction with a perturbed curtain of particles," keynote talk presented at the 9th International Conference on Computational & Experimental Methods in Multiphase & Complex Flow, Tallinn, Estonia, March 20, 2017. With R. González Izard, S. Reddy Lingampally, P. Wayne, and G. Jacobs.
- 34. "Unexpected features in shock-driven hydrodynamics," Los Alamos National Laboratory Physics/Theory Coloquium presented on March 8, 2018.
- 35. "Recent developments in studies of shock-accelerated multiphase flows," Fluid Dynamics Seminar, Imperial College, London, presented on May 17, 2018.

36. "Formation of a falling particle curtain," keynote talk presented at the 10th International Conference on Computational & Experimental Methods in Multiphase & Complex Flow, May 21 — 23, 2019, Lisbon, Portugal. With P. Wayne, S. Reddy Lingampally, G. Vigil, D. Freelong, and C. R. Truman.

Funded Research

Title: PIs: Funding Agency: Start Date: End Date: Funding Level: Summary:	Quantification of Disorder Growth in Transition to Turbulence P. Vorobieff Sandia National Laboratories 10/01/1999 09/30/2000 \$ 29,073 Develop advanced analysis methods using summation concepts for stud- ies of disorder growth in pre-turbulent mixing flows.
Title: PIs: Funding Agency: Start Date: End Date: Funding Level: Summary:	 PIV Diagnostics for Flow Control Applications P. Vorobieff (PI), C.R. Truman (co-PI) AFOSR 03/31/2000 03/30/2001 \$ 128,823 Develop capability for particle image velocimetry (PIV) diagnostics suitable for investigation of controlled flows.
Title: PIs: Funding Agency: Start Date: End Date: Funding Level: Summary:	Shock-induced Instability of a Thin Fluid Layer/Instabilities in Soap- Film Flows P. Vorobieff Los Alamos National Laboratory 06/05/2000 08/18/2000 \$ 24,337 Perform advanced-diagnostics experiments on fluid instabilities in two and three dimensions.
Title: PIs: Funding Agency: Start Date: End Date: Funding Level: Summary:	Hysteresis of Vortex-Shedding Behind a Circular Cylinder P. Vorobieff Oak Ridge Associated Universites 07/01/2000 07/01/2001 \$ 10,000 (50% cost-sharing) Investigate the recent claims of hysteretic behavior near the onset of Bénard - von Kármán instability.

Title: PIs: Funding Agency: Start Date: End Date: Funding Level: Summary:	 Shock-Driven Transition to Turbulence as a Code Validation Problem P. Vorobieff Sandia National Laboratories 10/01/2000 09/30/2001 \$ 35,000 Develop analysis methods for quantitative validation of numerical prediction of transition to turbulence. Provide a sample set of experimental benchmarks.
Title: PIs: Funding Agency: Start Date: End Date: Funding Level: Summary:	Experimental Flow Diagnostics and Numerical Prediction of Mixing in Chemical Lasers P. Vorobieff (PI), C.R. Truman (co-PI) DARPA 04/01/2001 08/31/2003 \$ 300,000 Develop an experimental system for quantitative diagnostics of flow inside a chemical laser. Examine the influence of flow hydrodynamics on laser performance. Perform numerical simulations.
Title: PIs: Funding Agency: Start Date: End Date: Funding Level: Summary:	 Experimental Study of Wake and Cavity Flows P. Vorobieff, C.R. Truman (subaward; program PIs: L. Crossey, D. Kauffman, program director: N. Vadiee) NASA PURSUE 01/01/2001 12/21/2001 \$ 25,630 Use advanced diagnostics for 2D hydrodynamics studies. Involve undergraduate students in research.
Title: PIs: Funding Agency: Start Date: End Date: Funding Level: Summary:	 Fluid Mechanics Studies for Aerodynamic Flow Control C.R. Truman, P. Vorobieff (subaward; program PIs: L. Crossey, D. Kauffman, program director: N. Vadiee) NASA PURSUE 06/01/2000 12/21/2001 \$ 32,750 Develop diagnostics for wind-tunnel studies of controlled flow. Involve undergraduate students in research.

Title: PI: Funding Agency: Start Date: End Date: Funding level: Summary:	 Experimental Analysis in Support of Physics-Based Validation P. Vorobieff Los Alamos National Laboratory 10/01/2001 09/30/2003 \$ 79,000 Perform experiments and analysis of experimental data to provide quantitative benchmarks for development of numerical codes predicting transition to turbulence.
Title: PIs: Funding Agency: Start Date: End Date: Funding level: Summary:	Flow Diagnostic System Development C.R. Truman (PI), P. Vorobieff (co-PI) Boeing 03/01/2002 09/30/2002 \$ 97,340 Instrumentation for a high-speed laser induced fluorescence system.
Title: PI: Funding Agency: Start Date: End Date: Funding level: Summary:	Experimental Analysis in Support of Physics-Based Validation P. Vorobieff Los Alamos National Laboratory 04/22/2003 04/30/2005 \$ 150,000 Perform experiments and analysis of experimental data to provide quantitative benchmarks for development of numerical codes predicting transition to turbulence.
Title: PI: Funding Agency: Start Date: End Date: Funding level: Summary:	 Bifurcations in a wedge flow V. Putkaradze (PI), P. Vorobieff (co-PI) Petroleum Research Foundation 06/01/2003 05/31/2006 \$ 80,000 Study of fundamental instabilities and bifurcations in wedge flows.

Title: PI: Funding Agency: Start Date: End Date: Funding level: Summary:	Predictions of HYSIM HF Laser Flow C.R. Truman (PI), P. Vorobieff (co-PI) Missiel Defense Agency via Boeing and AFRL 10/01/2003 09/30/2005 \$ 231,000 Experiment and numerics to understand mixing processes inside a
Title	chemical laser.
Thue.	Channels
PI: Funding Agency	V. Putkaradze (PI), P. Vorobieff (co-PI) US DOE
Start Date:	02/01/2004
End Date: Funding level:	01/31/2007 \$ 495.000
Summary:	Study of fundamental instabilities and bifurcations in wedge flows.
Title: PI:	Experimental and numerical studies of superhydrophobic surfaces A.A. Mammoli (PI), P. Vorobieff (co-PI)
Funding Agency:	Sandia National Laboratories
End Date:	05/01/2004 08/30/2005
Funding level: \tilde{a}	\$ 50,000
Summary:	Investigation of the possibility of macroscopic fluid slip on superhy- drophobic surfaces.
Title:	Localized scale coupling and new educational paradigms in multiscale mathematics and science
PIs:	M.S. Ingber (PI), P. Vorobieff (co-PI)
Funding Agency: Start Date:	US DOE 10/01/2005
End Date:	09/30/2008
Funding level:	\$ 345,000
Summary:	Experimental and numerical study of irreversibility in multiphase flows.

Title: PI: Funding Agency: Start Date: End Date: Funding level: Summary:	Experimental and numerical studies of superhydrophobic surfaces A.A. Mammoli (PI), P. Vorobieff (co-PI) Sandia National Laboratories 10/01/2005 09/30/2006 \$ 50,000 Investigation of macroscopic fluid slip on textured superhydrophobic substrates.
Title: PI: Funding Agency: Start Date: End Date: Funding level: Summary:	UNM Solar Power Testbed A.A. Mammoli (PI), P. Vorobieff (co-PI) State of New Mexico ENMRD 11/01/2005 10/31/2006 \$ 225,000 Construction and testing of a solar thermal system.
Title: PI: Funding Agency: Start Date: End Date: Funding level: Summary:	 PLIF diagnostics of iodine injection C.R. Truman (PI), P. Vorobieff (co-PI) DOD SBIR Phase I 03/01/2006 09/01/2006 \$ 30,000 Analysis of mixing in chemical laser.
Title: PI: Funding Agency: Start Date: End Date: Funding level: Summary:	 Analysis of PLIF images in iodine injection studies P. Vorobieff (PI), C.R. Truman (co-PI) DOD SBIR Phase II 01/01/2007 12/31/2008 \$ 30,000 Analysis of mixing enhancement in a chemical laser.
Title: PI: Funding Agency: Start Date: End Date: Funding level: Summary:	Studies of High-Speed Mixing Flows with Particulates F. Gilfeather (UNM lead PI), P. Vorobieff (PI), C.R. Truman (co-PI) DTRA 08/01/2007 07/31/2008 \$ 401,000 Construction of a tiltable shock tube, experiments with shock-driven multiphase flows.

Multiphase shock-driven hydrodynamic experiments for hydrocode val- idation P. Vorobieff (PI), C.R. Truman (co-PI) NNSA 01/01/2010 12/31/2012 \$ 539,080 Experiments to provide code-validation benchmarks for shock interac- tion with gas density interfaces and multiphase media.
Experimental and numerical studies of respirable particle transport sur- faces by acoustic/shock waves C.R. Truman (PI), P. Vorobieff (co-PI) DTRA 01/01/2010 12/31/2011 \$ 230,367 Experiments to provide code-validation benchmarks for shock interac- tion with gas density interfaces and multiphase media.
Optimization of UNM solar thermal plant A. Mammoli (PI), P. Vorobieff (co-PI), H. Barsun (co-PI) State of New Mexico ENMRD 03/21/2010 09/20/2011 \$ 128,000 Installation of booster mirrors and other components to improve solar collector efficiency.
 Attracting, Motivating and Preparing Mathematics students in the Southwest by building an energetic community of students and educators. M. Nitsche (PI), D. Appelo, P. Vorobieff et al. NSF 06/01/2012 05/30/2016 \$ 1,200,000

Title: PI: Funding Agency: Start Date: End Date: Funding level: Summary:	Collaborative research: Particle Dynamics in Viscous Shear Flows P. Vorobieff NSF 09/01/2013 08/30/2016 \$ 204,764 Experimental and numerical study of irreversibility in particle-carrying flow.
Title:	Shock-driven complex behavior of multiphase flow: dynamics of particles and droplets
PI:	P. Vorobieff (PI), C.R. Truman (co-PI)
Funding Agency:	NNSA
Start Date:	09/01/2013
End Date:	08/30/2016
Funding level:	\$ 399,956
Summary:	Experimental study of shock-driven multiphase flows.
Title: PI:	A 3D CFD model validation for candidate Mo-99 target geometry P. Vorobieff
Funding Agency:	LANL
Start Date:	10/01/2013
End Date:	09/30/2015
Funding level:	\$ 110,500
Summary:	Numerical study of a closed flow loop.
Title:	UNM Shock Tube Facility Upgrade
PI:	P. Vorobieff
Funding Agency:	UNM OVPR Equipment Fund
Start Date:	04/23/2014
End Date:	04/22/2015
Funding level:	\$ 50,906
Summary:	Equipment grant to upgrade flow visualization.

Title:	Ionization of Shocked Flow
PI:	P. Vorobieff
Funding Agency:	New Mexico Small Business Assistance Program
Start Date:	07/01/2015
End Date	09/30/2015
Funding level	\$ 8,000
Summary:	Experiments with a prototype jet engine (business partner: Dark Sea
Summary.	Indurstries LLC).
Title:	Quantification of normal and oblique shock-driven phase interaction
	and transition to turbulence in media with multiscale density interfaces
PI:	P. Vorobieff (PI), C.R. Truman (co-PI)
Funding Agency:	NNSA
Start Date:	08/01/2015
End Date:	07/31/2018
Funding level:	\$ 600,000
Summary:	Shock tube studies.
2 annual 9 i	
Title:	Collaborative research: Shock interaction with a complex hydrody-
	namic medium
PI:	P. Vorobieff
Funding Agency:	NSF
Start Date:	08/01/2016
End Date:	07/31/2020
Funding level:	\$ 240,001
Summary:	Shock-driven multiphase flow studies.
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Title:	Multiphase Flow Physics for Reduced Order Models
PI:	P. Vorobieff
Funding Agency:	DTRA
Start Date:	10/01/2017
End Date:	09/30/2020
Funding level:	\$ 1,050,000
Summary:	Three-university collaboration (UNM, NMT, UC) on shock-driven mul-
v	tiphase flow studies. UNM share -38% .

Title:	Characterization and Mitigation of Radiative, Convective, and Particle Losses in High Temperature Particle Receivers
Ъŀ	P Vorobieff (PI) A Mammoli (co-PI)
Funding Agency	Sandia National Laboratories
Start Date	05/10/2018
End Date:	05/21/2020
End Date.	¢ 200 000
Funding level.	Optimization study for concentrating solar newsr porticle receiver
Summary.	Optimization study for concentrating solar power particle receiver.
Title:	Radiation Emissivity Measurements
PI:	P. Vorobieff (PI)
Funding Agency:	Sandia National Laboratories
Start Date:	11/12/2018
End Date:	09/31/2019
Funding level:	\$ 60,000
Summary:	Emissivity studies for material samples.
Title:	Efficient Microgravity Heat and Mass Transfer
PI:	P. Vorobieff (UNM PI)
Funding Agency:	NASA
Start Date:	05/01/2020
End Date:	04/30/2023
Funding level	\$ 100,000
Summary.	Orbital pavload development
Summary.	
Title:	Research Partnership with UNM
PI:	T. Khraishi (PI), P. Vorobieff (co-PI)
Funding Agency:	Sandia National Laboratories
Start Date:	01/01/2020
End Date:	09/30/2020
Funding level:	\$ 75,000
Summary:	Sample shear tests.
Title:	Hypervelocity MHD jet engine
PI:	P. Vorobieff
Funding Agency:	New Mexico Small Business Assistance
Start Date:	01/01/2020
End Date:	12/31/2020
Funding level	\$ 7 500
Summary.	Energy-efficient ionization experiments for MHD propulsion
Summary.	Energy enterent formation experiments for write propulsion.

Title:	Harvesting the energy of a planetary or stellar magnetosphere for space
	propulsion
PI:	P. Vorobieff
Funding Agency:	New Mexico Small Business Assistance
Start Date:	01/01/2020
End Date:	12/31/2020
Funding level:	\$ 7,500
Summary:	Energy-efficient ionization experiments for MHD propulsion.
Title:	Characterization and Mitigation of Radiative, Convective, and Particle
Title:	Characterization and Mitigation of Radiative, Convective, and Particle Losses in High Temperature Particle Receivers
Title: PI:	Characterization and Mitigation of Radiative, Convective, and Particle Losses in High Temperature Particle Receivers P. Vorobieff (PI), A. Mammoli (co-PI)
Title: PI: Funding Agency:	Characterization and Mitigation of Radiative, Convective, and Particle Losses in High Temperature Particle Receivers P. Vorobieff (PI), A. Mammoli (co-PI) Sandia National Laboratories
Title: PI: Funding Agency: Start Date:	Characterization and Mitigation of Radiative, Convective, and Particle Losses in High Temperature Particle Receivers P. Vorobieff (PI), A. Mammoli (co-PI) Sandia National Laboratories 10/01/2020
Title: PI: Funding Agency: Start Date: End Date:	Characterization and Mitigation of Radiative, Convective, and Particle Losses in High Temperature Particle Receivers P. Vorobieff (PI), A. Mammoli (co-PI) Sandia National Laboratories 10/01/2020 03/31/2021
Title: PI: Funding Agency: Start Date: End Date: Funding level:	Characterization and Mitigation of Radiative, Convective, and Particle Losses in High Temperature Particle Receivers P. Vorobieff (PI), A. Mammoli (co-PI) Sandia National Laboratories 10/01/2020 03/31/2021 \$ 34,000