

Frank Herbert Muldoon

Contact Information

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http://tetra.fluid.tuwien.ac.at/fmuldoo/public_html/webpage/frank-muldoon.html

Vienna Technical University

Institute of Fluid Mechanics and Heat Transfer

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Personal Data

Citizenship:

America, Ireland

Date of birth:

November 27, 1971

Languages:

English (native), Russian

Marital status:

Married, two sons

Education

Doctorate: Mechanical Engineering

5/2004

Minor: Mathematics and Computer Science

Louisiana State University, Baton Rouge, LA 70803

Dissertation: *Numerical Methods for the Unsteady Incompressible Navier-Stokes Equations and their Application to the Direct Numerical Simulation of Turbulent Flows*

http://etd.lsu.edu/docs/available/etd-03022004-015240/unrestricted/Muldoon_dis.pdf

Bachelor of Science: Mechanical Engineering

5/1996

Louisiana State University, Baton Rouge, LA 70803

Research Interests

- 1) Applications of the Direct Numerical Simulation of turbulent flows
 - Mixing processes of jets in crossflow
 - Film-cooling applications of jets in crossflow
 - Turbulence model development using Direct Numerical Simulation data
 - Surface tension (Marangoni effect) and buoyancy driven flows
- 2) Optimization in conjunction with the unsteady Navier-Stokes equations
 - Optimization algorithms and strategies appropriate for the unsteady Navier-Stokes equations
 - Efficient solvers for the adjoint equations
 - Applications of combining optimization with the unsteady Navier-Stokes equations
 - Control of turbulence
 - Control of surface tension (Marangoni effect) and buoyancy driven flows
- 3) Numerical methods for the Direct Numerical Simulation of turbulent flows
 - Immersed boundary methods for complex and moving geometries
 - Efficient solvers suitable for parallel computer architectures

- 4) High performance computing
- Development of software suitable for Direct Numerical Simulation on parallel computer architectures
 - Interactive and immersive visualization of large-scale simulations

Professional Experience

Institute of Fluid Mechanics and Heat Transfer

10/2009-Present

Researcher: Vienna Technical University, Austria

- Modeling of surface tension driven flows (Marangoni effect) using Tetra, FLUENT[®], OpenFOAM and NEK5000
- Continued maintaining, developing and improving the CFD code Tetra
- Added the ability to solve control/optimization problems concerning surface tension and buoyancy driven flows to Tetra
- Investigated the effect of controlling models of crystal growth through free surface heating using Tetra
- Aided graduate students in developing and using CFD models to address various problems

InvenTherm

7/2007-9/2009

CFD consultant: Baton Rouge LA; work was accomplished in Petrozavodsk, Russia

- Created structured (Gambit[®] and GridPro[®]) and unstructured (Gambit[®]) grids for models of compressors
- Modeled compressors using FLUENT[®]
- Created structured and unstructured grids for models of compressors using ICEM[®] and CFX-Mesh[®] for modeling of unsteady fluid-structure problems
- Solved unsteady fluid-structure problems using ANSYS[®]/CFX[®]

Center for Computation and Technology

3/2004-8/2009

Research Associate Level III: Louisiana State University, Baton Rouge, LA

- Performed numerous studies combining optimization with heat transfer and fluid flow
- Continued maintaining, developing and improving the CFD solver Tetra
- Added the ability to solve optimization problems to Tetra by developing an adjoint solver
- Taught students to use Tetra
- Investigated the affect of jet-pulsation on film-cooling and mixing jets
- Developed a new mass conserving scheme for the immersed boundary method
- Analyzed results by creating informative movies of unsteady flow using Tecplot[®]
- Member of Computer Policy committee managing High Performance Computing machines

Computational Fluid Dynamics Research Group

6/1996-3/2004

Research Assistant: Department of Mechanical Engineering, Louisiana State University, Baton Rouge, LA

- Developed from scratch the computer program Tetra, which is a three-dimensional unsteady flow solver that incorporates the immersed boundary method and unsteady particle tracking
- Parallelized Tetra using domain decomposition and MPI
- Developed a multi-grid solver for the collocated version of Tetra
- Assisted others in the Computational Fluid Dynamics group to use Tetra to solve various flow problems
- Used Tetra to solve a number of flows using Direct Numerical Simulation, generally with heat transfer; Flows included pulsed jets in crossflow, film-cooling jets, channel flow and flow over a backstep
- Used Tetra extensively on supercomputers such as the IBM SP2, SP3, SP4, SP5, SGI Origin 3000, Compaq GS40, Cray SV1 and large scale Linux clusters
- Used Tecplot[®]'s macro language to generate large numbers of movies from the unsteady results of Tetra to aid in understanding the effects of applying pulsing to jets in crossflow

- Purchased the components for and assembled an 80 node Beowulf type parallel computer system, used by the computational fluid dynamics group
- Performed system administration and maintenance duties on Linux and Unix systems including the parallel machine described above
- Used INS3D, a block structured solver to solve jets in crossflow for film-cooling applications
- Organized a weekly CFD seminar at which graduate students and faculty presented results

Air Force Jet Propulsion Laboratory

5/2001-7/2001

Computational Fluid Dynamics Analyst, summer internship: Wright Patterson Air Force Base, OH

- Analyzed the suitability of the immersed boundary method for simulating unsteady flows in turbines
- Used super-computers such as the IBM SP3 and Compaq GS40 to perform simulations using Tetra

Dow Chemical Hydrocarbons Math Modeling Group

12/1998-03/2000

Computational Fluid Dynamics Analyst: Plaquemine, LA

- Generated grids for very complex geometries using the structured multi-block grid generator GridPro[®]
- Modeled industrial problems, most of which involved chemically reacting flows, using CFX[®] and Chem3d

Department of Mechanical Engineering Fluid Dynamics Laboratory

8/1994-8/1995

Student worker: Louisiana State University, Baton Rouge, LA

- Designed and built system to determine globe valve loss coefficients
- Performed the experiments to determine the loss coefficients

Louisiana National Guard, 3671 Maintenance Company

8/1989-8/1996

Military Occupational Specialty 63H, Tracked Vehicle Mechanic, Camp Beauregard, LA

- Performed all levels of maintenance on tracked and wheeled combat vehicles
- Member of Louisiana National Guard state pistol marksmanship team

Publications

Refereed Journal Publications

Direct Numerical Simulation of Pulsed Jets in Crossflow, Frank Muldoon and Sumanta Acharya, Computers and Fluids, Volume 39, Issue 10, December 2010, Pages 1745-1773

DNS Study of Pulsed Film Cooling for Enhanced Cooling Effectiveness, Frank Muldoon and Sumanta Acharya, International Journal of Heat and Mass Transfer, June 2009, Volume 52, Issues 13-14, pp. 3118-3127

Control of a Simplified Unsteady Film-cooling Flow Using Gradient-based Optimization, Frank Muldoon, AIAA Journal, 2008, Volume 46, Issue 10, pp 2443-2458

A Divergence-Free Interpolation Scheme for the Immersed Boundary Method, Frank Muldoon and Sumanta Acharya, International Journal for Numerical Methods in Fluids, 2007, Volume 56, Issue 10, pp. 1845-1884

A Modification of the Artificial Compressibility Algorithm with Improved Convergence Characteristics, Frank Muldoon and Sumanta Acharya, International Journal for Numerical Methods in Fluids, 2007, Volume 55, Issue 4, pp. 307-345

Analysis of k-e Budgets for Film Cooling Using Direct Numerical Simulation, Frank Muldoon and Sumanta Acharya, AIAA Journal, 2006, Volume 44, Issue 12, pp 3010-3021

Dynamics of Large-Scale Structures for Jets in a Crossflow, Frank Muldoon and Sumanta Acharya, ASME Journal of Turbomachinery, 1999, Volume 121, pp 557-587

Refereed Conference Publications

Computations of Pulsed Film-cooling, Frank Muldoon and Sumanta Acharya, ASME TURBO EXPO 2007, GT2007-28156

On Active Control of Film-Cooling Flows, Dimitris Nikitopoulos, Sumanta Acharya, Jeremiah Oertling and Frank Muldoon, ASME TURBO EXPO 2006, GT2006-90051

Mass Conservation in the Immersed Boundary Method, Frank Muldoon and Sumanta Acharya, 2005 ASME Fluids Engineering Division Summer Meeting and Exhibition, FEDSM2005-77301

Direct Numerical Simulation of a Film Cooling Jet, Frank Muldoon and Sumanta Acharya, ASME TURBO EXPO 2004, GT2004-53502

From RANS to DNS: Application to Film Cooling, Sumanta Acharya, Mayank Tyagi, Asif Hoda and Frank Muldoon, 26th National Conference on Fluid Mechanics & Fluid Power, 15 - 17th Dec 1999

Numerical Investigation of the Dynamical Behavior of a Row of Square Jets in Crossflow over a Surface, Frank Muldoon and Sumanta Acharya, ASME TURBO EXPO '98, 98-GT-019

Invited Publications

Direct Numerical Simulation of Pulsed Jets in Cross-Flow, Frank Muldoon, published in the Navigator, a bi-annual technical publication of the Naval Oceanographic Office, Spring 2004

Under review/in preparation

Maximization of Mass flow in a Channel Obstructed by an Infinitely Thin Plate Using a Control Strategy Applied to the Unsteady Navier-Stokes Equations, Frank Muldoon, submitted July 2009 to the International Journal for Numerical Methods in Fluids

Control of Hydrothermal Waves in a Thermocapillary Flow Using a Gradient-based Control Strategy, Frank Muldoon, in preparation

Minimization of Torque Acting on an Infinitely Thin Plate Using a Control Strategy Applied to the Unsteady Navier-Stokes Equations, Frank Muldoon, in preparation

Grants

Control of thermocapillary flows within the framework of the Japanese--European Research Experiment on Marangoni Instability (JEREMI) **Under review**

European Union's Marie-Curie fellowship program, PI: Frank Muldoon, project duration 3/1/2011-3/1/2013, submitted 8/17/2010

Engineering Marangoni Flows by Heat-Transfer Management and Flow Control **Under review**
European Space Agency, PI: Hendrik Kuhlmann, Co-PI: Frank Muldoon and Michael Lukasser, requested €380,384, project duration 1/1/2011-1/1/2013, submitted 5/28/2010

Onset of convection and development of non-linear regimes under the influence of the Soret effect in a saturated porous layer in the presence of inclined thermal and salinity gradients **Under review**
French National Research Agency and the Austrian Science Fund, PI: Leonid Brevdo (France) and Hendrik Kuhlmann (Austria), Co-PI: Frank Muldoon, requested €581,590, project duration 36 months, submitted 4/14/2010

Active Control of Transverse Jets for Film-Cooling Application **Awarded**
Air Force Office of Scientific Research, PI: Dimitris Nikitopoulos, Co-PI: Frank Muldoon and Sumanta Acharya, contract # FA9550-05-1-0219, award amount \$220,000, 3/1/2006-11/30/2009

Optimization of Film Cooling Jets in Cross-flow **Awarded**
Frank Muldoon and Sumanta Acharya, NSF Partnership in Advanced Cyber-infrastructure (NSF-PACI), 95,000 hours/units, 2005-2006

Real-Time Feedback Control of Film Cooling Application through Integrated Parallel Field Simulations and Measurements **Declined**
National Science Foundation, PI: Sumanta Acharya, Co-PI: Frank Muldoon, Blaise Bourdin, Guoxiang Gu and Dimitris Nikitopoulos, proposal # 0540361, requested amount \$1,633,815, submitted 09/27/2005

Optimal Open Loop Forcing of Jets-in-Cross-Flow (JICF): A DNS/LES Study **Declined**
National Science Foundation, PI: Sumanta Acharya, Co-PI: Frank Muldoon, proposal # 0522948, requested amount \$362,945, submitted 06/15/2005

Direct Numerical Simulation of Jets in Engine Flows **Awarded**
NASA, PI: Sumanta Acharya, Co-PI: Frank Muldoon, contract # NGT13-52755127405135, award amount \$21,500, 7/1/2002-6/30/2003

Awards

Best Presentation, Graduate Student Seminar Series, Mechanical Engineering Department, Louisiana State University, 2003

Louisiana State University Board of Regents Fellowship, August 1996 - August 2000

Software Skills

- CFX[®]
- CFX-Mesh[®]
- FLUENT[®]
- Fortran 77/95
- Gambit[®]
- OpenFOAM
- GridPro[®]
- ICEM[®]
- Matlab[®]
- Mathcad[®]
- Perl
- VisIt
- Shell programming and scripting
- Tecplot[®]
- Tecplot[®] macro language
- Totalview[®] debugger
- NEK5000
- MPI