Numerical Methods Research

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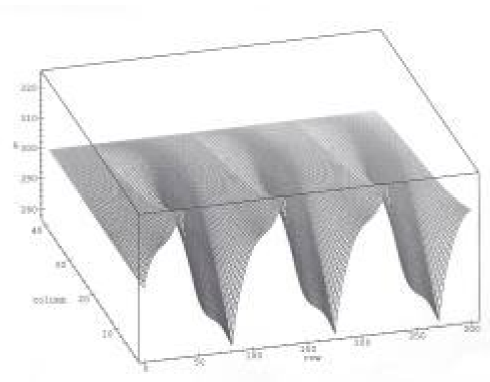
Zhonghai Ding

- Professor of Mathematics
  Department of Mathematical Sciences
- Ph.D. in Mathematics
  Texas A&M University, College Station, Texas
- CDC 1004, Zhonghai.Ding@unlv.edu
- https://faculty.unlv.edu/zding/

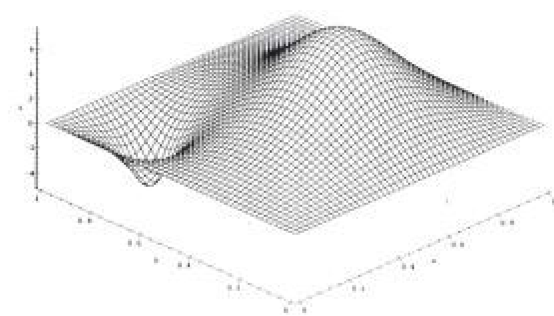
Areas of Expertise

- Control Theory
- Partial Differential Equation
- Mathematical Modeling
- Numerical Computation



Research Summary:

Dr. Ding’s research interests are in mathematical modeling and analysis, control, and computation of problems arising from real applications such as nematic liquid crystals, suspension bridge systems, shape memory alloys, oxidation of metal matrix composites, control of dynamical systems, etc.. These systems are governed by linear or nonlinear partial differential equations. Dr. Ding’s research focus on analyzing system behaviors, developing numerical methods for solutions, and investigating related control issues.



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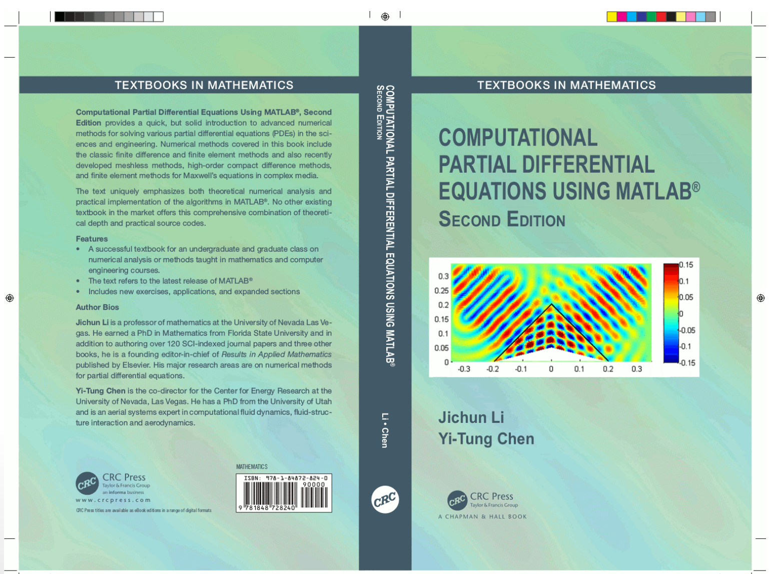
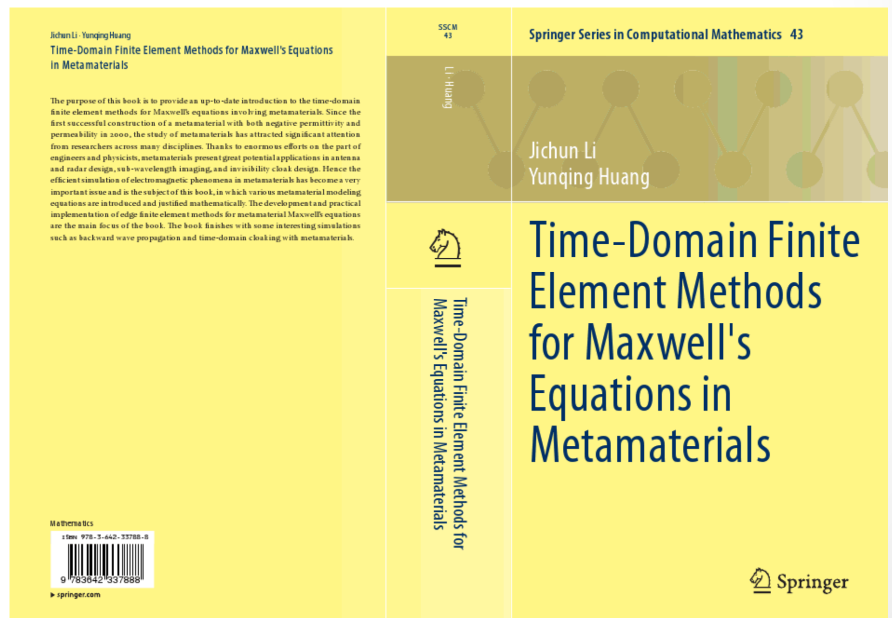
Scientific Computing and Mathematical Modeling

Dr. Jichun Li
Department of Mathematical Sciences
Phone: (702)895-0365
Email: jichun.li@unlv.edu

Expertise:

Computational Electromagnetics
Numerical Methods for PDEs
Mathematical Modeling





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Jichun Li et al (Mathematical modeling and analysis of optical black hole with metamaterials): Computer Methods in Applied Mechanics and Engineering 204 (2016) 501-520.

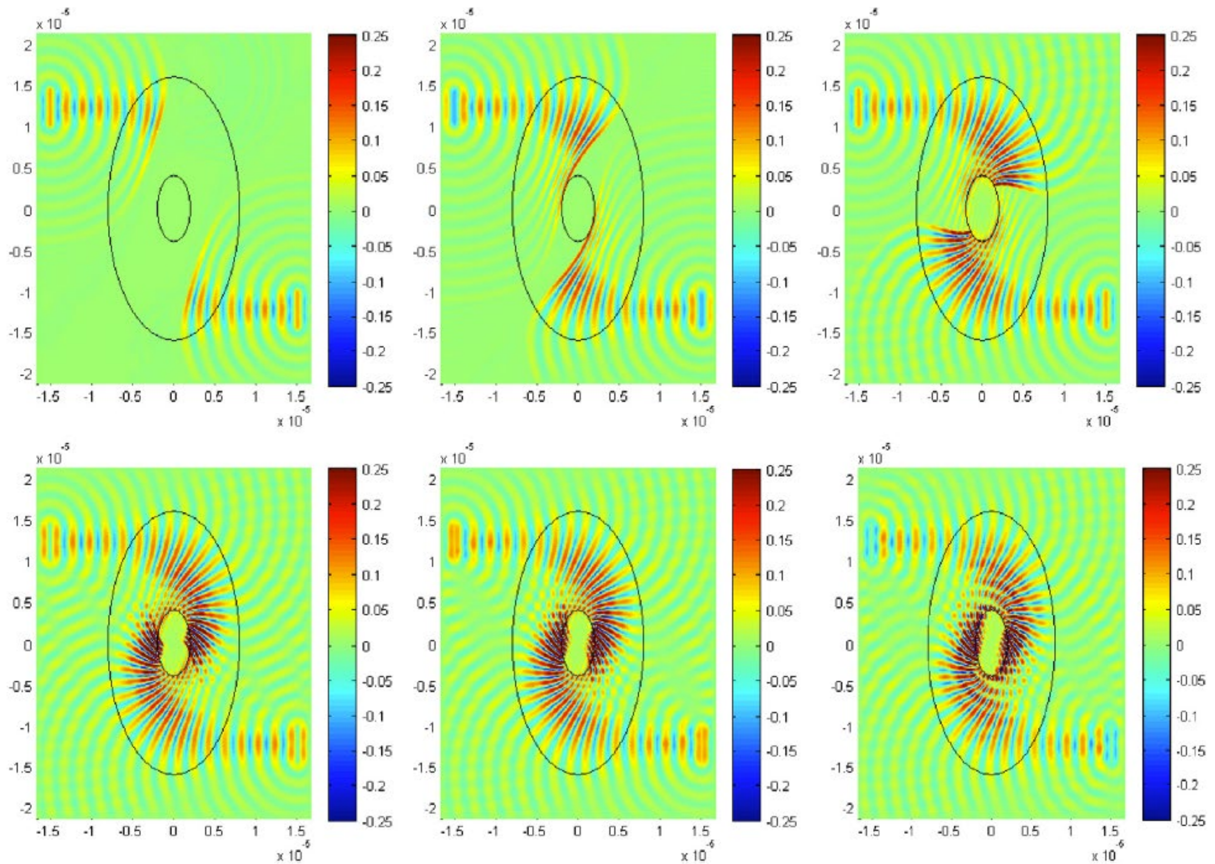
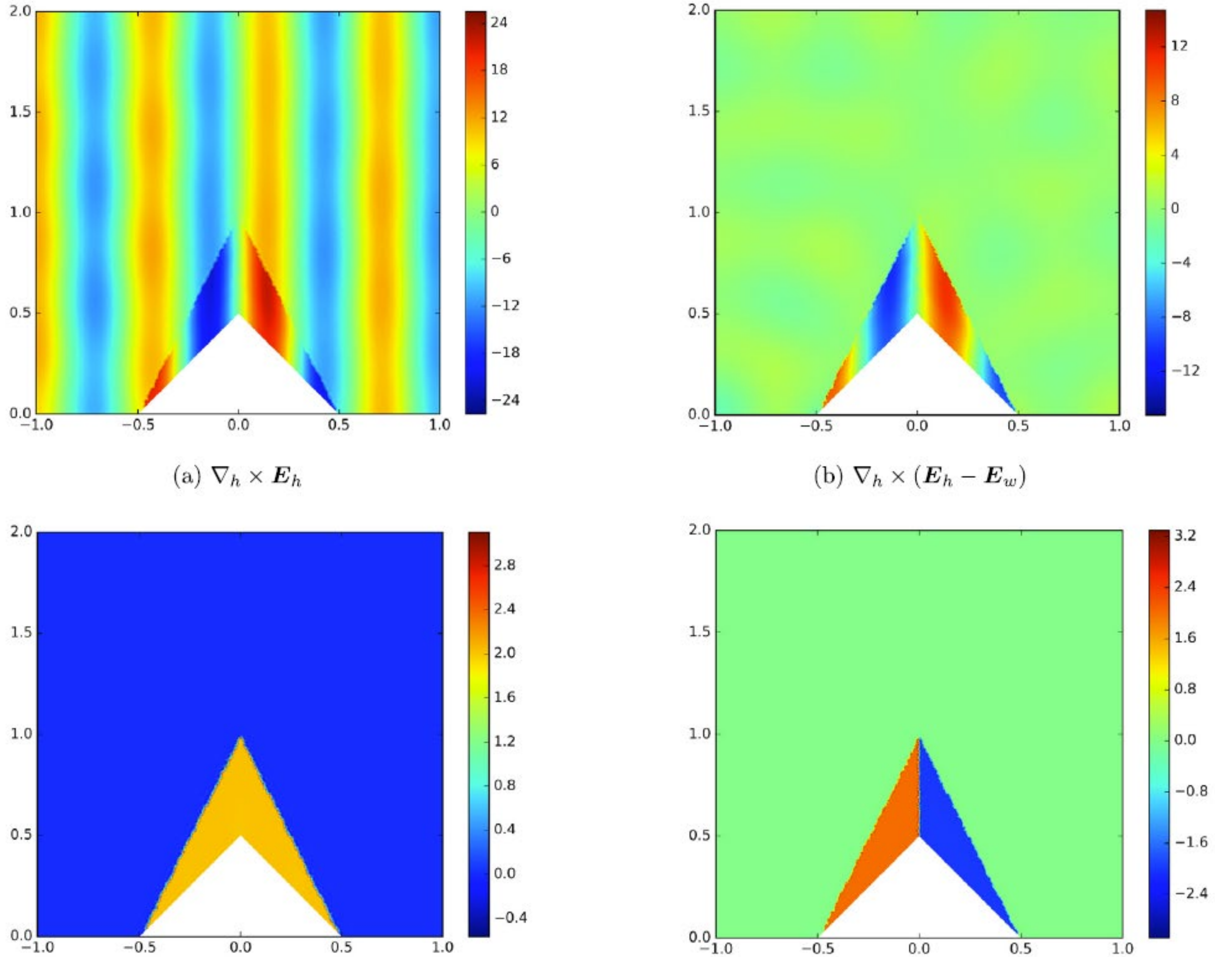


Fig. 4.5. Example 2. Magnetic fields H_z at various time steps for the elliptical OBHs simulation. Top left: 1600 steps. Top middle: 2400 steps. Top right: 3600 steps. Bottom left: 4800 steps. Bottom middle: 5200 steps. Bottom right: 8000 steps.

Jichun Li et al (Optimal control for electromagnetic cloaking metamaterial design): Computer and Mathematics with Applications 79 (2020) 1165-1176.



(a) $\nabla_h \times \boldsymbol{E}_h$

(b) $\nabla_h \times (\boldsymbol{E}_h - \boldsymbol{E}_w)$

(c) Optimized ϵ_1, exact $\epsilon_1 = 2$
$\min \epsilon_1 = 2.00617032$ and $\max \epsilon_1 = 2.00996683$

(d) Optimized ϵ_2, exact $\epsilon_2 = -2 \cdot \text{sgn}(x)$
$\min \epsilon_2 = -2.00261751$ and $\max \epsilon_2 = 2.02687675$

Computational Fluid Dynamics

- **Dr. Monika Neda**
- Professor, Department of Mathematical Sciences
- monika.neda@unlv.edu
- https://faculty.unlv.edu/neda/

Expertise

- Computational Fluid Dynamics
- Turbulence
- Numerical Methods for Partial Differential Equations
- Applied Sensitivity Analysis

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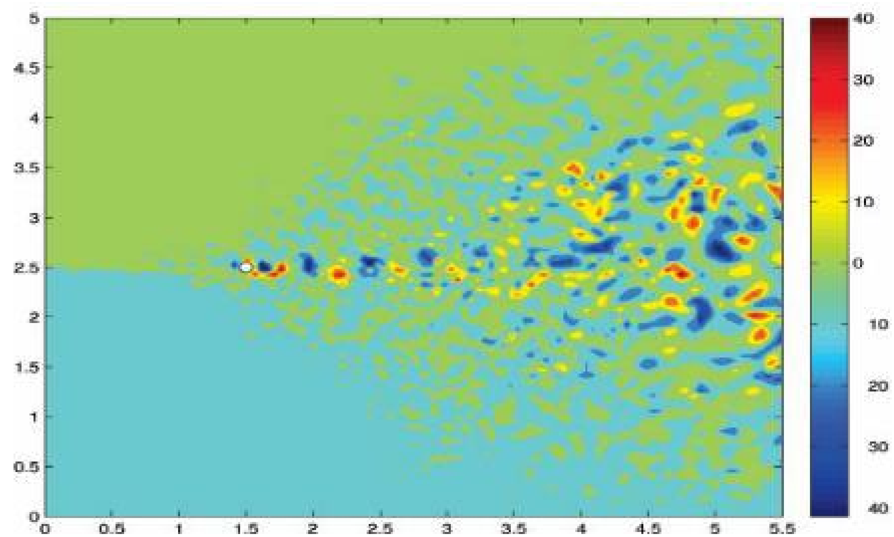
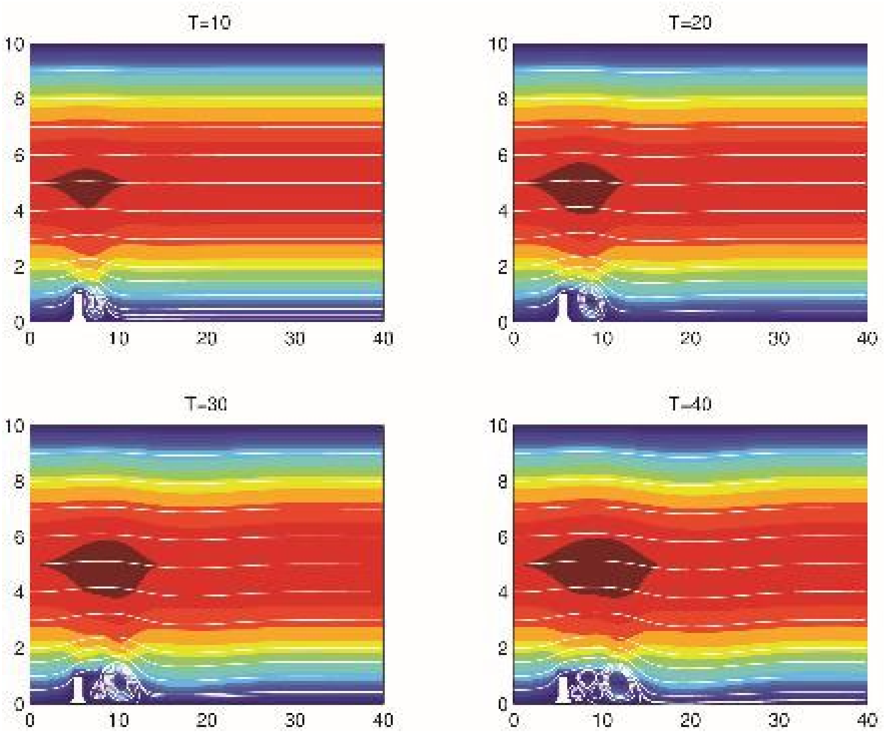
Simulation of fluid flow past an obstacle: Calculations of drag and lift

My research focuses on the theoretical and computational studies of fluid flow models that are based on Navier-Stokes equations. These studies include derivation of the energy (in) equality, model's micro-scale, boundary layer investigation, stability of the model's numerical solution, finite element error estimates, sensitivity computations and simulations of benchmark fluid flow problems.

The figure below presents the creation of the vortex street behind an immersed body in a fluid. It can be used to compute drag and lift in aerodynamics, such as drag and lift of aircrafts.



Simulation of fluid flow past an obstacle: Creation of eddies/vortices behind the step



The above figure depicts the creation of the rotational structures behind the step as a result of the interaction of the fluid with boundaries.

Advanced Numerical Methods for Moving Domain/Interface Multi-Physics Problems

Dr. Pengtao Sun
Professor
Department of Mathematical Sciences
Email: pengtao.sun@unlv.edu ; URL: https://faculty.unlv.edu/sun/

Expertise

- Numerical Solutions of Partial Differential Equations (PDE)
- Numerical Analysis (Well-posedness, Stability, Convergence)
- Finite Element/Volume/Difference Methods
- Scientific and Engineering Computing
- Fluid-Structure Interaction (FSI) Modeling and Simulation
- Fuel Cell Dynamics, Fluid Dynamics, Electrohydrodynamics

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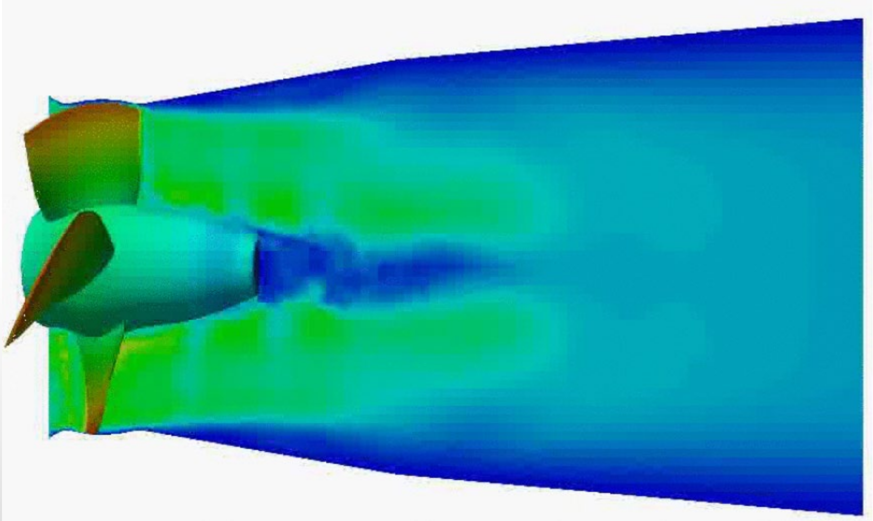
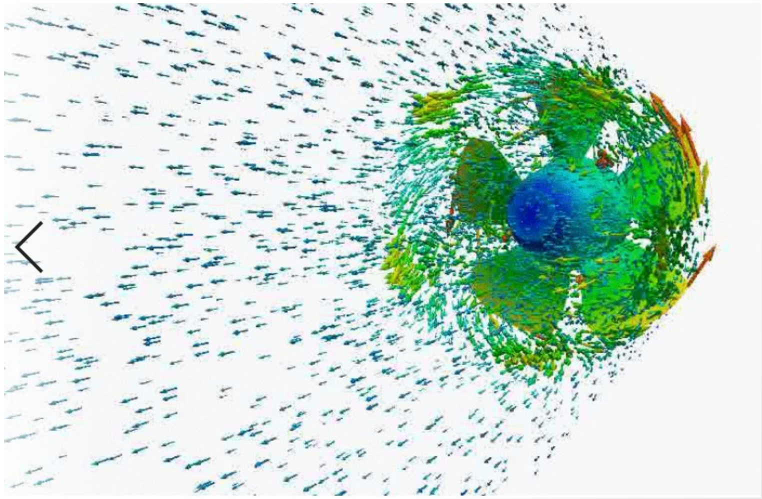
Fluid-Hydro Turbine Interaction Problems

- Hydroelectric power generating system produces renewable energy and remains crucial for society and industry. The most significant part of this system is the hydro turbine interacting with the water flow, which involves elastic solid materials and viscous fluids and belongs to the category of fluid-structure interaction (FSI). The developments of mathematical models and numerical methodologies are critical in practice for efficient simulations of the hydro turbine, which in turn guides the design and evaluation.
- We approach the challenges in different aspects. First, based on the observation that the hydro turbine, although exhibiting large rotations, has relatively small deformation, we develop linearized elasticity equations that alleviate the burden on nonlinear solver and improves the well-posedness of spatial discretization. Second, we propose a new approach to solve the arbitrary Lagrangian-Eulerian mesh motion for rotating structure. Moreover, we analyzed the well-posedness and convergence of the finite element discretization and demonstrated the discretization is solver friendly.





Hemodynamic Fluid-Structure Interaction (FSI) Problems

- FSI simulation has become the most promising solution method to solve the hemodynamic problem existing in the clinical cardiovascular system. However, the complexity of cardiovascular environment, the artificial heart pump model, the vascular rupture, the aneurysm progression and the aortic dissection cause the deficiency of the existing FSI simulation package towards the clinical demands.
- We devoted our research to the new modeling and numerical techniques for the bloodstream-vascular-stent graft/artificial heart pump interaction problems, aiming at overcoming numerical difficulties and challenges, and developed advanced numerical methodologies to improve the efficiency and accuracy of corresponding FSI simulations. and to deliver more instructive numerical results to medical professionals for helping out patients on an efficient and accurate diagnosis and treatment.