Adam C. DeVoria

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Research Interests

My research interests are varied among several areas within fluid dynamics, such as aero/hydrodynamics, inviscid flow modeling, vortex dynamics, multi-phase interface physics, and bio-inspired propulsion. Each area of interest is unified, however, by the pursuit of making novel scientific contributions that provide new understanding at a fundamental level. My work is a combination of theoretical and experimental efforts. On-going and future research seeks to develop simplified models of fluid regions exhibiting rapid variations in physical quantities, whereby the regions are replaced with mathematical discontinuities.

Education

Ph.D. Aerospace Engineering **2013**
University at Buffalo
Advisor: Prof. Matthew Ringuette
Dissertation: *On the flow generated by rotating flat plates of low aspect ratio*

M.S. Mechanical Engineering **2011**
University at Buffalo
Advisor: Prof. Matthew Ringuette
Thesis: *Vortex formation in the starting flow of rotating, low-aspect-ratio plates*

B.S. Aerospace and Mechanical Engineering **2004–2008**
University at Buffalo
Notes: dual degrees, Cum Laude

Teaching Experience

Assistant Professor: The Citadel School of Engineering **August 2022 – Present**
- MECH 101: Introduction to Mechanical Engineering
- MECH 102: Engineering Computer Applications
- MECH 330: Measurements and Instrumentation with Lab
- MECH 350: Modeling and Analysis of Dynamical Systems I
- MECH 351: Modeling and Analysis of Dynamical Systems II
- MECH 415: Heat Transfer
- MECH 470: Introduction to Applied Aerodynamics
- MECH 476: Propulsion Systems

Instructor: The Citadel School of Engineering **August 2021 – August 2022**

Instructor: University at Buffalo **Summer 2012**
- Undergraduate Heat Transfer (MAE 336)

Teaching Assistant: University at Buffalo **2008-2012**
- MAE 424: Aerodynamics (2 semesters)
- MAE 335: Fluid Mechanics (2 semesters)
- MAE 336: Hear Transfer
- MAE 423: Introduction to Propulsion

Substitute Lecturer for Prof. Mohseni: University of Florida **2014-2019**
- Fluids I (Unit: Fluid dynamic force on moving bodies)
- Fluids II (Unit: Stokes Flow, 2 semesters)
- Sources of Vorticity (Unit: Vorticity in Animal Flight and Swimming)

Publications

Journal Articles (refereed)

13. **A. C. DeVoria**, "General solution for self-similar mixing layers", ***ASME J. Fluids Engineering***, 144(12), 121302, 2022. (link)

12. **A. C. DeVoria** and K. Mohseni, "Theoretical model for the separated flow around an accelerating flat plate using time-dependent self similarity", ***Physical Review Fluids***, 6, 054701, 2021. (link)

11. **A. C. DeVoria** and K. Mohseni, "New insights from inviscid modelling of starting flow separation with roll-up", ***Journal of Fluid Mechanics***, 903, A24, 2020. (link)

10. **A. C. DeVoria** and K. Mohseni, "The vortex-entrainment sheet in an inviscid fluid: theory and separation at a sharp edge", ***Journal of Fluid Mechanics***, 866, 660-688, 2019. (link)

9. **A. C. DeVoria** and K. Mohseni, "Vortex sheet roll-up revisited", ***Journal of Fluid Mechanics***, 855, 299-321, 2018. (link)

8. **A. C. DeVoria** and K. Mohseni, "On the mechanism of high-incidence lift generation for steadily translating low-aspect-ratio wings", ***Journal of Fluid Mechanics***, 813, 110-126, 2017. (link)

7. **A. C. DeVoria** and K. Mohseni, "A vortex model for forces and moments on low-aspect-ratio wings in side-slip with experimental validation", ***Proceedings of the Royal Society A***, 473(2198), 110-126, 2017. (link)

6. **A. C. DeVoria** and K. Mohseni, "Droplets in an axisymmetric microtube: effects of aspect ratio and fluid interfaces", ***Physics of Fluids***, 27(1), 012002, 2015. (link)

5. Carr Z. R., **A. C. DeVoria**, and M. J. Ringuette, "Aspect-ratio effects on rotating wings: circulation and forces", ***Journal of Fluid Mechanics***, 767, 497-525, 2015. (link)

4. **A. C. DeVoria**, Carr Z. R., and M. J. Ringuette, "On calculating forces from the flow field with application to experimental volume data", ***Journal of Fluid Mechanics***, 749, 297-319, 2014. (link)

3. **A. C. DeVoria** and M. J. Ringuette, "The force and impulse of a flapping plate performing advancing and returning strokes in a quiescent fluid", ***Experiments in Fluids***, 54(5), 1515, 2013. (link)

2. **A. C. DeVoria** and M. J. Ringuette, "On the flow generated on the leeward face of a rotating plate", ***Experiments in Fluids***, 54(4), 1495, 2013. (link)

1. **A. C. DeVoria** and M. J. Ringuette, "Vortex formation and saturation for low-aspect-ratio rotating flat-plate fins", ***Experiments in Fluids***, 52(2), 441-462, 2012. (link)

Conference Papers (acceptance by review)

9. J. T. Thalakkottor and **A. C. DeVoria**, "Modeling a shock front as an extended dividing hypersurface", AIAA Paper 2023-2481, ***AIAA SciTech***, National Harbor, MD, January 23-27, 2023.

8. G. Elamin, M. Bubacz, **A. DeVoria**, R. Rabb, D. Ragan, and P. Niksiar, "Student-Instructor Academic Relationships: Effects of Background and Culture", ASEE Paper 103, ***ASEE Southeastern Section Conference***, Charleston, SC, March 13-15, 2022.

7. **A. C. DeVoria** and K. Mohseni, "Desingularized trailing-edge shedding from a flat plate with a point vortex method", AIAA Paper 2018-0355, ***56th AIAA Aerospace Sciences Meeting***, Kissimmee, FL, January 8-12, 2018.

6. P. Zhang, **A. C. DeVoria**, and K. Mohseni, "Methods for Controlling Vorticity Generation at the Triple Contact Line for Wake and Drag Mitigation". ***31st Symposium on Naval Hydrodynamics***, Monterrey, California, September 11-16 2016.

5. **A. C. DeVoria** and K. Mohseni, "The effect of aspect ratio on the near-wake flow of rectangular wings", AIAA Paper 2016-0857, ***54th AIAA Aerospace Sciences Meeting***, San Diego, CA, January 4-8, 2016.

4. **A. C. DeVoria** and K. Mohseni, "Vortex structure of low-aspect-ratio wings in sideslip", AIAA Paper 2015-396, ***53rd AIAA Aerospace Sciences Meeting***, Kissimmee, FL, January 5-9, 2015.

3. **A. C. DeVoria**, P. Zhang, and K. Mohseni, "Simple model for low-aspect-ratio droplets in an axisymmetric microchannel", AIAA Paper 2014-1273, ***52nd AIAA Aerospace Sciences Meeting***, National Harbor, MD, January 13-17, 2014.

2. Carr. Z.R., **A. C. DeVoria**, and M. J. Ringuette, “Aspect ratio effects on the leading-edge circulation and forces of rotating flat-plate wings”, AIAA Paper 2013-0675, ***51st AIAA Aerospace Sciences Meeting***, Grapevine, TX, January 7-10, 2013.

1. **A. C. DeVoria**, P. Mahajan, and M. J. Ringuette, “Vortex formation and saturation for low-aspect-ratio rotating flat plates at low Reynolds number”, AIAA Paper 2011-396, ***49th AIAA Aerospace Sciences Meeting***, Orlando, FL, January 4-7, 2011.

Presentations

12. **A. C. DeVoria**. “A complex variable boundary element method for principal value integrals”, ***75th Annual Meeting of the APS DFD***, Indiana, IN, November 2022.

11. **A. C. DeVoria**. “A new quadrature for vortex sheet motion”, ***74th Annual Meeting of the APS DFD***, Phoenix, AZ, November 2021.

10. **A. C. DeVoria** and K. Mohseni. “A novel model to capture the flow asymmetry of an accelerating plate at incidence”, ***73rd Annual Meeting of the APS DFD***, Chicago, IL, November 2020.

9. **A. C. DeVoria**, J. J. Thalakkottor, and K. Mohseni, “Interfaces with mass: applications to vortex sheet dynamics and slip boundary conditions in viscous flows”, ***The second joint SIAM/CAIMS annual meeting***, Toronto, Canada, July 6-10, 2020.

8. **A. C. DeVoria** and K. Mohseni. “Self-similar roll-up of vortex-entrainment sheets”, ***72nd Annual Meeting of the APS DFD***, Seattle, WA, November 2019.

7. **A. C. DeVoria** and K. Mohseni. “The vortex-entrainment sheet”, ***71st Annual Meeting of the APS DFD***, Atlanta, GA, November 2018.

6. **A. C. DeVoria** and K. Mohseni. “Vortex doublet as a mechanism of shedding for inviscid methods”, ***70th Annual Meeting of the APS DFD***, Denver, CO, November 2017.

5. P. Zhang, **A. C. DeVoria**, and K. Mohseni. “Vorticity dipoles and a theoretical model of a finite force at the moving contact line singularity”, ***70th Annual Meeting of the APS DFD***, Denver, CO, November 2017.

4. **A. C. DeVoria** and K. Mohseni. “High lift generation of low-aspect-ratio wings”, ***69th Annual Meeting of the APS DFD***, Portland, OR, November 2016.

3. **A. C. DeVoria** and K. Mohseni. “The effects of aspect ratio on the flow invariants of droplets in an axisymmetric microtube”, ***67th Annual Meeting of the APS DFD***, San Francisco, CA, November 2014.

2. **A. C. DeVoria** and M. J. Ringuette. “Vortex formation in the starting flow of rotating low-aspect-ratio plates”, ***63rd Annual Meeting of the APS DFD***, Long Beach, CA, November 2010.

1. **A. C. DeVoria**, J. Bapst, and M. J. Ringuette. “Vortex formation time for a sweeping fin”, ***62nd Annual Meeting of the APS DFD***, Minneapolis, MN, November 2009.

Research Accomplishments

Postdoctoral Research (Univ. Florida, 2013–2021)

1. **Low-aspect-ratio wing aerodynamics**

   ○ *I developed a theory to explain high-incidence lift generation of low-aspect-ratio wings.*
   - Showed that the downwash of the tip vortex flow reattaches leading-edge shear layer as well as aids in satisfying a (time-averaged) Kutta condition at the trailing edge.
   - This decreases strength/amount of vorticity shed and maintains an **effective bound circulation** resulting in Joukowski-type lift generation

   ○ *I conceived a simple vortex model for the forces and moments exerted on rectangular wings of variable aspect ratio, angle of attack, and sideslip angle.*
   - The merging tip vortices in the zero-aspect-ratio limit represented by a **vortex dipole**.
   - Theoretically derived a **parabolic** lift/circulation distribution instead of the elliptical distribution of classical aerodynamic theory.

- Results were validated with volumetric stereo-PIV reconstructions of the flow field and direct force measurements.

2. **Inviscid flow modeling**
   - *I developed a new inviscid model for viscous boundary and shear layers termed a* **vortex-entrainment sheet**.
     - The dynamic model superimposes a vortex sheet representing vorticity in the layer with an entrainment sheet representing the **mass and momentum** in the layer.
     - The sheet is characterized by **discontinuities** in tangential velocity (harmonic potential) as well as **normal velocity** (stream function).
     - The 'intrinsic flow' confined to the sheet has mass per-unit-area and may support a pressure jump.
     - Proved that the **shedding angle** for flow around a sharp edge can be **non-tangential** to the edge face when entrainment occurs.
   - *I applied the* **vortex-entrainment sheet** *model to study* **viscous effects** *of starting flow separation.*
     - Formulated the generalized problem for flow around a sharp wedge to include entrainment boundary conditions.
     - Entrainment significantly augments the solution space that is more restricted by classical potential flow using the no through-flow assumption.
     - Obtained the asymptotic solution in order to derive an analytical expression for the shedding angle.
     - Entrainment on the freely shed sheet can represent diffusive as well as inertial effects.
     - Successful comparison with experiments indicates ability of model to capture viscous effects.

3. **Multi-phase microfluidics**
   - *I designed, built and conducted micro-PIV experiments to measure the recirculating flow inside translating droplets in a microchannel*
     - The objective was to assess the effect of introducing fluid interfaces on the global flow invariants (circulation, impulse, kinetic energy) for droplets of different length.
     - Decreasing the droplet length increases the magnitude of the invariants as compared to a continuous flow 'slug' of the same length.
     - Also increased are the average rates at which invariants are advected along the channel.
   - *I assisted a graduate student in the design and construction of a 'dynamic Wilhelmy plate' experiment for their dissertation work. The experimental set-up included:*
     - Optical measurement of the contact line angle.
     - PIV system for flow field measurement.
     - Laser displacement device for beam deflection measurement.

Graduate Research (Univ. Buffalo, 2008-2013)

Bio-inspired propulsion

- *I experimentally investigated the 3-D, unsteady development and vortex dynamics produced in the starting flow of rotating, low-aspect-ratio flat plates.*
  - Characterized the root-to-tip flow of rotating fins and the ensuing vortex break-down process.
  - Detailed the force and impulse generation for different bio-propulsive kinematics and orientations.
  - Revealed and quantified the increasing contribution to lift generation from the tip vortex for rotating wings as their aspect ratio is decreased.
  - Applications of results are to autonomous underwater vehicles using fin-like propulsors and micro aerial vehicles using wing-like propulsors.
- *I derived the 'objective origin' method to minimize errors in the calculation of forces on a moving body from velocity field measurements. The method:*
  - Determines a spatial origin based on the satisfaction of mathematical identities with experimental data.
  - Provides significant improvement in calculated forces with measured forces.
  - Offers a validity check based on statistics and probability in the absence of direct measurements.

Technical Skills

- Competency in technical writing
- Comfortable with public speaking
- Research grant writing
- Wind/water tunnel operation
- Planar PIV
- Stereo PIV
- micro PIV
- LabVIEW
- Matlab
- Maple
- LaTeX