Rapid Simulation of Fluid Energy Systems to Enable Optimization and Design

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ABSTRACT:

Fluid energy systems affect everyone every day, such as in the transport of commercial goods and the production of electricity. The design and optimization of such systems is facilitated by rapid simulation tools, which are built upon low-order models. This talk discusses the development of such low-order models for the design of flapping-wing propellers and turbines: By introducing viscous effects into traditionally-inviscid "singularity methods", we have created models that are accurate and robust, yet 10,000 times faster than full-blown RANS or LES simulations. In addition to creating viscous singularity methods, we have also explored the use of "Boltzmann kinetics" as a framework for creating rapid simulation tools. In this thread of the talk, we derive the "fractional Laplacian" as a model for the friction force arising in a turbulent flow. This novel turbulence model is exciting, because it analytically predicts the logarithmic "Law of the Wall" in shear turbulence. Taken together, this talk explores computational simulation at multiple levels of fidelity, with the goal of enabling rapid simulation, design, and optimization of fluid energy systems.

Biography: Dr. Brenden Epps is an assistant professor of engineering at the Thayer School of Engineering at Dartmouth College. Prof. Epps' research advances frontiers at the intersection of fluid mechanics and energy systems: marine propulsion, hydrokinetic energy conversion, and liquid biofuels. Prof. Epps is a mechanical engineer by training (B.S. CMU, M.S. MIT, Ph.D. MIT) and has practical industry experience at Ford Motor Company. Prof. Epps' doctoral and postdoctoral research focused on experimental hydrodynamics: fish swimming and maneuvering, free-surface flows, and marine propeller design. He is the author of OpenProp, open-source software for screw propeller and turbine design that has thousands of users worldwide. Prof. Epps teaches undergraduate and graduate courses in fluid mechanics, applied mathematics, and aircraft design.